NASA

National Aeronautics and Space Administration

Budget Estimates

FISCAL YEAR 1980

Volume I

Agency Summary

Research and Development

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NATIONAL AERONAUTICS AND SPACE ADMINISTMTION

FISCAL YEAR 1980 ESTIMATES

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SUMMARY

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautics activities for peaceful purposes for the benefit of all. NASA's activities are designed to maintain United States leadership in aeronautical and space research, technology, and utilization, and more specifically to:

-- Extend our knowledge of the Earth, its environment, the solar system, and the universe;

-- Expand the practical applications of space technology;

-- Develop, operate, and improve manned and unmanned space vehicles;

-- Improve the civil and military usefulness of aeronautical vehicles, while minimizing their environmental effects and energy consumption;

-- Disseminate pertinent findings to potential users; and

-- Promote international cooperation in peaceful activities in space.

In October 1978, the President announced the civil space policy for the next decade which will include a balanced strategy of applications, science and technology development designed to:

-- Emphasize space applications that will bring important benefits to our understanding of Earth resources, climate, weather, pollution and agriculture;

-- Emphasize space science and exploration in a manner that retains challenge and excitement and permits the Nation to retain the vitality of its space technology base;

-- Take advantage of the flexibility of the Space Shuttle to reduce the cost of operating in space;

-- Increase benefits for resources expended through better integration and technology transfer among the national space programs;

-- Assure American scientific and technological leadership in space;

-- Demonstrate advanced technological capabilities in open and imaginative ways;

-- Foster space cooperation with nations by conducting joint programs;

-- Confirm our support of the continued development of a legal regime for space that will assure its safe and peaceful use for the benefit of all.

The FY 1980 budget provides for progress in achievement of these objectives at a pace consistent with other Federal objectives and overall fiscal constraints. Basic emphasis is on effective and efficient accomplishment of currently approved programs in the practical applications of space capabilities to problems on Earth, in the exploration of space, in the expansion of human knowledge and in advancing the technology necessary to United States leadership in space and aeronautics.

The budget for FY 1980 has been developed on the assumption that a FY 1979 Supplemental Appropriation of $185.0 million will be approved to provide timely support for the Space Shuttle program. The total budget authority required for FY 1979, including this Supplemental Appropriation and the Supplemental October 1978 civil service pay raise is $4,566.2 million. The appropriations requested for FY 1980 total $4,725.0 million. Civil service staffing levels are planned at 22,831 at the end of FY 1979 and 22,563 at the end of FY 1980.

Space Shuttle

The Space Shuttle is the key element of the Space Transportation System which will open up a new era in Earth-oriented observations, scientific exploration, and technology advances. The Shuttle system will dramatically increase the capabilities and flexibility of space operations while decreasing the cost for all users -- NASA, DOD, other Government agencies, universities, commercial firms, and international groups.

Development and test of the Space Shuttle system have progressed significantly during 1978. Approach and landing tests using the orbiter test vehicle, the Enterprise, have been successfully completed and the Enterprise is now at the Marshall Space Flight Center where it is being used in conjunction with the external tank and solid rocket boosters in full system ground vibration test. The first orbiter flight vehicle is nearing completion at Palmdale, California. This orbiter will achieve the first orbital flight, which will be launched from the Kennedy Space Center. The first series of main propulsion system tests, with three engines firing simultaneously, has been completed at the National Space Technology Laboratories. The main engine has been fired more than 10,000 seconds at the rated power level of 100%. In addition, external tank and solid rocket booster flight hardware for the first orbital flight is nearing completion.

Progress at this critical phase of the Shuttle development effort has been substantial, but has not sustained the pace necessary to accomplish the plan reflected in the original FY 1979 budget. Technical problems and increased requirements in the contractor and subcontractor activities, which have been encountered as the ground test and fabrication efforts intensified, have made it necessary to adjust the program schedules and to request the supplemental appropriation in FY 1979. The FY 1980 budget request, which assumes the supplemental appropriation in FY 1979, reflects delays compared to the original FY 1979 budget plan of approximately six months in the initial orbital flight and approximately nine months in the initial operational capability.

Key areas of emphasis in the FY 1980 budget other than the Space Shuttle include:

Aeronautical Research and Technology

The FY 1980 budget continues a balanced program to provide the research and technology base required to improve aircraft performance, safety, and economy while reducing their energy requirements and environmental effects; to maintain the strong competitive position of the United States in the world marketplace; and to support the Department of Defense in maintaining the superiority of the Nation's military aircraft. The FY 1980 program focuses on:

- Strengthening the research and technology base, which is the reservoir of basic knowledge for enhancing the growth of the new and improved aeronautical capabilities on which the Nation's continued leadership in aeronautics depends.
- Continued progress in the aircraft energy efficiency efforts, which are aimed at providing, in the 1980's, the improved technology leading to a major reduction in fuel requirements for transport aircraft.
- Continued research into reducing noise and pollution and improving safety and terminal area operations.

Applications

The FY 1980 budget provides the resources to conduct a carefully coordinated and logically phased set of research and development activites that demonstrate and transfer the applications of space-based technology, systems and related capabilities for down-to-Earth, practical benefits. The FY 1980 program provides for continued progress toward these objectives in the key areas of Remote Sensing, Materials Processing and Communications. Ongoing efforts in the Remote Sensing area include: development of the Landsat-D system to advance Earth resources technology; the Earth Radiation Budget Experiment to acquire valuable data for climate studies on a global basis; and the Halogen Occultation Experiment, an instrument to provide improved pollution monitoring capabilities. These major development efforts are integrated with and based on a comprehensive program of research and analysis to develop and demonstrate ground-based applications of the data acquired by remote sensing techniques. NASA will undertake, in conjunction with the Departments of Agriculture, Commerce and Interior, and the Agency for International Development, a program of agricultural research designed to increase our knowledge of domestic and foreign crop conditions and our commodity production estimates.

In the Materials Processing area, the FY 1980 program provides for continued development of equipment and related activities for experiments to be conducted on initial Spacelab missions and for enhancement of research activities.

In Communications, the FY 1980 program includes continued progress on the Search and Rescue Mission, augmentation of advanced communications research activities, and definition studies on an experimental wideband communications satellite to operate in the newly allocated 20/30 GHz spectral bands.

Space Science

Programs in Space Science are directed toward increasing our knowledge and understanding of life processes, the Earth and its space environment, the planets, the sun, other stars, and the universe. The N 1980 program provides for advances in research and analysis activities and for continued progress on approved missions. These projects include: the Solar Maximum Mission, which will study solar flares and related phenomena during the peak period of the solar cycle; the Space Telescope, which will increase by several hundredfold the portion of the universe accessible for observation; the International Solar Polar Mission, a cooperative effort with the European Space Agency, which will study the polar regions of the sun and contribute to our understanding of the interactions between the sun and Earth and their effects on the Earth's weather and climate; and the Galileo mission, which will carry a probe to make the first detailed measurements of the atmosphere of the giant planet Jupiter and instruments to conduct extensive orbital observations of Jupiter and its satellites.

Space Research and Technology

The FY 1980 program provides for an enhancement of Research and Technology Base activities to provide critical advanced technology in key disciplinary areas. The program also supports systems technology efforts, including experiments to be conducted on the Shuttle Orbiter and Spacelab, the second phase of the NASA End-to-End Data System technology, and work on technology for space structures and materials, propulsion and advanced communications.

Summary

NASA's FY 1980 budget request provides for progress at a constrained pace toward the goals stated in the President's Space policy and toward maintaining United States leadership in civil and military aircraft technology.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

	Budget Plan FY 1978	FY 1979	FY 1980
RESEARCH AND DEVELOPMENT			
Space Transportation Systems........	1,751,500	2,009,500	1,904,000
Space shuttle........	1,349,200	1,628,300 a/	1,366,000
Space flight operations........	267,800	309,700	467,300
Expendable launch vehicles........	134,500	71,500	70,700
Space Science........	404,700	505,400	601,600
Physics and astronomy........	224,200	282,900	337,500
Planetary exploration........	147,200	182,400	220,200
Life sciences........	33,300	40,100	43,900
Space and Terrestrial Applications........	243,900	283,900	344,400
Space applications........	234,800	274,800	332,300
Technology utilization........	9,100	9,100	12,100
Aeronautics and Space Technology........	333,200	376,400	419,700
Aeronautical research and technology........	228,000	264,100	300,300
Space research and technology........	97,700	107,300	116,400
Energy technology........	7,500	5,000	3,000
Tracking and Data Acquisition........	278,300	302,000	332,800
TOTAL RESEARCH AND DEVELOPMENT........	3,011,600	3,477,200	3,602,500
CONSTRUCTION OF FACILITIES........	162,340	147,500	157,600
RESEARCH AND PROGRAM MANAGEMENT........	889,506	941,469 b/	964,900
TOTAL........	4,063,446	4,566,163	4,725,000
OUTLAYS........	3,983,119	4,404,100	4,595,000

a/ Includes proposed supplemental of $185,000,000 for Space Shuttle.
b/ Includes proposed supplemental of $30,969,000 for October 1978 pay increase.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION SYSTEMS

- Develop a Space Transportation System to provide for:

  -- Versatile and reusable Space Shuttle system
  -- Manned orbital experiments using Shuttle and Spacelab
  -- Deep space and geosynchronous mission capability with upper stages
  -- Orbital placement, servicing and retrieval of automated satellites
  -- Economy in transportation, space operations, and payload costs

- Continue production to provide a national fleet of Space Shuttle orbiters

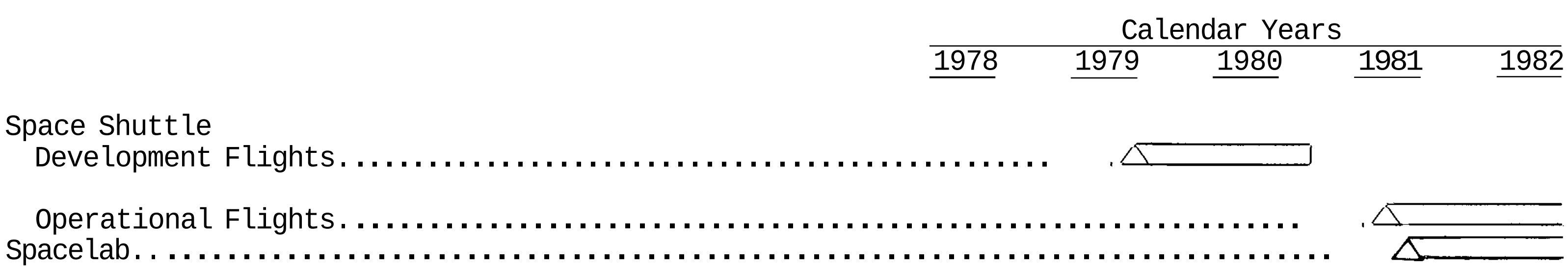
- Establish capability for Space Transportation System operations

- Conduct Shuttle orbital flight tests

- Conduct design and verification activities for Shuttle thrust augmentation

- Provide expendable launch vehicle services as required by NASA and other users during transition to Space Transportation System

MAJOR FLIGHT ACTIVITY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE

- Increase our understanding of the evolution and nature of the universe through a balanced program of space exploration missions and ground-based investigations

- Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained

- Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields

MAJOR FLIGHT ACTIVITY

	Calendar Years					
	1978	1979	1980	1981	1982	1983
Physics and Astronomy:						
High Energy Astronomy Observatory	△	△				
Solar Maximum Mission		△				
Space Telescope						△
International Solar Polar Mission						△
Shuttle/Spacelab Science Payloads			△	△———	———	———
Explorer Launches	△△		△	△△△△△	△	
Planetary Exploration:						
Voyager-Jupiter/Saturn Encounters		Ⓙ Ⓙ	Ⓢ	Ⓢ		
Pioneer-Saturn Flyby		Ⓢ				
Pioneer-Venus Orbiter Launch and Encounter	△ Ⓥ					
Pioneer-Venus Probe Launch and Encounter	△ Ⓥ					
Galileo-Jupiter Launch and Encounter					△	Ⓙ 1985
Life Sciences:						
Shuttle/Spacelab Experiments (including Vestibular Function Research)						△———

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE AND TERRESTRIAL APPLICATIONS

- Develop and demonstrate practical uses of space and space-derived technology

  -- Resource observations
  -- Environmental observations
  -- Materials processing in space
  -- Space communications

- Accelerate the transfer of NASA-developed research and technology advances to public and private sectors

MAJOR FLIGHT ACTIVITY

	Calendar Years					
	1978	1979	1980	1981	1982	1983
Landsat-3	A					
Heat Capacity Mapping Mission	△					
Landsat-D				△		
Magnetic Field Satellite		△				
SEASAT	△					
Nimbus-7	△					
Stratospheric Aerosol and Gas Experiment		△				
TIROS-N	A					
Search and Rescue Satellite Systems Test					△ ——	——
Earth Radiation Budget Experiment					△ ——	——
Shuttle/Spacelab Applications Payloads			△	△ ——	——	——

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Provide a technology base for current and future civil and military aircraft to:

  -- Reduce energy requirements

  -- Improve performance

  -- Increase safety

  -- Decrease environmental effects

  -- Reduce cost

- Achieve these objectives, by means of ground and flight-based research and technology activities, through advances in the technology areas of:

  -- Materials and structures

  -- Propulsion

  -- Avionics and flight control

  -- Aerodynamics

  -- Operations

  -- Man-vehicle interactions

- Major technology focus:

  -- Aircraft Energy Efficiency Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

- Provide a technology base to enable and enhance future space activities by:
  - -- Improving performance
  - -- Reducing cost
  - -- Increasing reliability

- Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:
  - -- Materials and structures
  - -- Electronics
  - -- Chemical and electric propulsion
  - -- Space power systems
  - -- Component standardization

MAJOR FLIGHT ACTIVITY

	Calendar Years					
	1978	1979	1980	1981	1982	1983
Space Technology Shuttle/Spacelab Payloads						

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ENERGY TECHNOLOGY

- Energy technology activities to facilitate use of NASA-developed aerospace technologies, experience and facilities to meet the program needs of the Department of Energy and other agencies responsible for energy programs

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:

  -- Automated Earth Orbiting Missions - Covering an average of approximately 50 applications and scientific spacecraft, the support workload will include Nimbus 5,6, & 7, the Landsat missions, Heat Capacity Mapping Mission, International Ultraviolet Explorer, International Sun Earth Explorer missions, the High Energy Astronomy Observatory missions, and the Applications 'Technology Satellite missions

  -- Planetary Missions - In addition to seven Pioneer spacecraft, Helios 1 & 2 and Voyager 1 & 2 will also be supported

  -- Shuttle Orbital Flight Tests

  -- Sounding Rockets

  -- Aeronautical Flight Research Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

SUMMARY OF APPROPRIATIONS
(Thousands of Dollars)

Appropriations	FY 1978 PL 95-119	FY 1979 PL 95-392	FY 1980 Request
Research and Development	3,011,600	3,477,200	3,602,500
Basic appropriation	3,013,000	3,292,200	3,602,500
Transfer to Construction of Facilities appropriation	-1,400	---	---
Proposed supplemental for Space Shuttle	---	185,000	---
Construction of Facilities	162,340	147,500	157,600
Basic appropriation	160,940	147,500	157,600
Transfer from Research and Development appropriation	1,400	---	---
Research and Program Management	889,761	941,469	964,900
Basic appropriation	844,000	910,500	964,900
Supplemental appropriation for civilian pay raises (PL 95-355)	45,761	---	---
Proposed supplemental for civilian pay raises	---	30,969	---
Total	4,063,701	4,566,169	4.725.000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YFAR 1980 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

Fiscal Year 1978	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 95-119..	4,017,940	3,013,000	160,940	844,000
Transfer from Research and Development to Construction of Facilities....	---	-1,400	1,400	---
Supplemental Appropriation, PL 95-355.....	45,761	---	---	45,761
Unobligated balance lapsing.	-255	---	---	-255
Total Budget Plan..	4,063,446	3,011,600	162,340	889,506
Fiscal Year 1979				
Appropriation, PL 95-392	4,350,200	3,292,200	147,500	910,500
Proposed supplemental for Space Shuttle...	185,000	185,000	---	---
Proposed supplemental for civilian pay raises...	30,969	---	---	30,969
Total Budget Plan,..	4,566,169	3,477,200	147,500	941,469
Fiscal Year 1980				
Appropriation request/budget plan	4,725,000	3,602,500	157,600	964,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION
(Millions of Dollars)

	TOTAL			Research and Development			Facilities			Research and Program Management		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Johnson Space Center........	1,121.1	1,297.2	1,257.7	969.0	1,141.3	1,096.6	5.4	1.9	4.9	146.7	154.0	156.2
Kennedy Space Center........	339.8	362.3	355.1	170.1	225.6	201.9	55.9	15.8	25.0	113.8	120.9	128.2
Marshall Space Flight Center.	790.0	917.5	934.2	622.6	752.5	764.2	23.9	16.7	21.1	143.5	148.3	148.9
National Space Technology Laboratories..............	24.4	25.0	20.4	20.0	19.2	13.3	1.7	1.3	2.4	2.7	4.5	4.7
Goddard Space Flight Center.	619.0	641.1	69S.1	487.2	504.9	560.4	7.9	8.0	3.5	123.9	128.2	131.2
Jet Propulsion Laboratory...	207.0	254.7	319.9	199.4	248.5	316.3	7.6	6.2	3.6	---	---	---
Wallops Flight Center..	33.1	-32.4	36.6	16.1	16.1	16.5	2.0	.8	3.8	15.0	15.5	16.3
Ames Research Center........	185.4	235.6	248.4	112.6	128.4	140.5	15.1	43.4	42.1	57.7	63.8	65.8
Dyrden Flight Research Center	37.9	35.1	41.2	18.6	13.6	18.2	1.1	1.9	3.2	18.2	19.6	19.8
Langley Research Center.. ...	290.1	286.0	305.0	158.7	144.9	171.0	29.4	33.2	23.9	102.0	107.9	110.1
Lewis Research Center..	223.7	247.9	265.8	134.6	148.8	161.4	4.2	6.6	8.6	84.9	92.5	95.8
Headquarters................	186.6	219.7	230.1	102.7	133.4	142.2	2.8	---	---	81.1	86.3	87.9
Undistributed Construction of Facilities:												
Various Locations.........	1.8	---	---				1.8	---	---			
Space Shuttle Facilities...	---	1.9	---				---	1.9	---			
Repair....................							---	---	.2			
Rehabilitation and Modification............	2.2	2.1	1.3				2.2	2.1	1.3			
Minor Construction........	---	1.1	---				---	1.1	---			
Facility Planning and Design..................	1.3	6.6	14.0				1.3	6.6	14.0			
Total Budget Plan.......	4.063.4	4.566.2	4.725.0	3.011.6	3.477.2	3,602.5	162.3	147.5	157.6	889.5	941.5	964.9

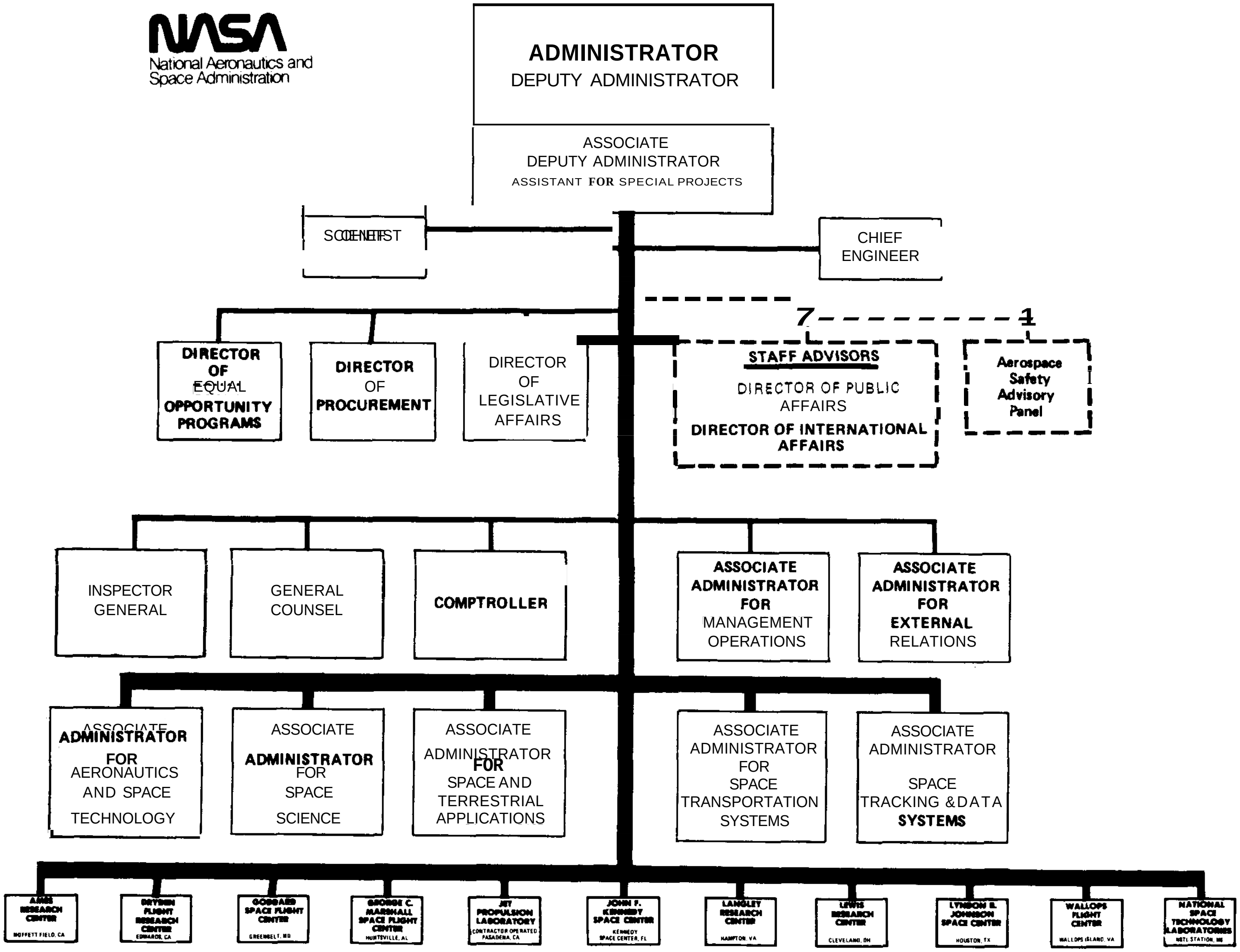
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

	FY 1978 Actual	FY 1979	FY 1980
Johnson Space Center	3.532	3,509	3.445
Kennedy Space Center	2.179	2,193	2.187
Marshall Space Flight Center	3.760	3.636	3.561
National Space Technology Laboratories	102	104	103
Goddard Space Flight Center	3.575	3.468	3.440
Wallops Flight Center	407	398	395
Ames Research Center	1.669	1.666	1.653
Dryden Flight Research Center	490	480	461
Langley Research Center	3.071	3.015	2.990
Lewis Research Center	2.921	2.858	2.835
Headquarters	1.531	1,504	1,493
Total, Permanent Positions	23.237	22.831	22.563


NASA
National Aeronautics and Space Administration
ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSOCIATE DEPUTY ADMINISTRATOR
ASSISTANT FOR SPECIAL PROJECTS
CHIEF SCIENTIST
CHIEF ENGINEER
DIRECTOR OF EQUAL OPPORTUNITY PROGRAMS
DIRECTOR OF PROCUREMENT
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STAFF ADVISORS
DIRECTOR OF PUBLIC AFFAIRS
DIRECTOR OF INTERNATIONAL AFFAIRS
Aerospace Safety Advisory Panel
INSPECTOR GENERAL
GENERAL COUNSEL
COMPTROLLER
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT OPERATIONS
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE
ASSOCIATE ADMINISTRATOR FOR SPACE AND TERRESTRIAL APPLICATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
ASSOCIATE ADMINISTRATOR SPACE TRACKING & DATA SYSTEMS
AMES RESEARCH CENTER
MOFFETT FIELD, CA
DRYDEN FLIGHT RESEARCH CENTER
EDWARDS, CA
GODDARD SPACE FLIGHT CENTER
GREENBELT, MD
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, AL
JET PROPULSION LABORATORY
CONTRACTOR OPERATED
PASADENA, CA
JOHN F. KENNEDY SPACE CENTER
KENNEDY SPACE CENTER, FL
LANGLEY RESEARCH CENTER
HAMPTON, VA
LEWIS RESEARCH CENTER
CLEVELAND, OH
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HOUSTON, TX
WALLOPS FLIGHT CENTER
WALLOPS ISLAND, VA
NATIONAL SPACE TECHNOLOGY LABORATORIES
NSTL STATION, MS

RESEARCH
AND DEVELOPMENT

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the practical applications of space technology; to develop, operate and improve manned and unmanned space vehicles; to provide technology for improving the performance of aeronautical vehicles while minimizing their environmental effects and energy consumption; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE TRANSPORTATION SYSTEMS: A program to provide all the transportation and related capabilities required to conduct space operations. The major development objective is the reusable Space Shuttle, the key element of a versatile, economical transportation system to provide a wide variety of users with round trip access to space during the 1980's and beyond.

SPACE SCIENCE: A program utilizing space systems, supported by ground-based and airborne observations, to conduct a broad spectrum of scientific investigations. The objective is to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, as well as the other stars of our galaxy and the universe.

SPACE AND TERRESTRIAL APPLICATIONS: A program, using space, aircraft, and ground-based systems, to identify and demonstrate the useful applications of space techniques in the areas of remote sensing to acquire information which will assist in solution of Earth resources and environmental problems; advanced communications satellite systems technology; and materials processing research and experimentation. The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology and development programs.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental research and to develop the technology required to maintain United States leadership in aeronautics and space. The program also provides for identification and evaluation of elements of NASA's aeronautics and space technology which can benefit National energy programs.

TRACKING AND DATA ACQUISITION: A program, utilizing a worldwide network, to support Earth orbital, deep space, suborbital and aeronautical activities.

SPACE TRANSPORTATION SYSTEMS

Space Transportation Systems activities provide all the transportation and associated support capabilities required to conduct space operations. These activities currently focus on the development and testing of the Space Shuttle--the first reusable space vehicle and the key element of a versatile, economical Space Transportation System to provide domestic and international users with round trip access to space for the 1980's and beyond.

The Space Shuttle is the most important element of the Space Transportation System. Its versatility and reusability will open up a new era in expanding the uses of space for a wide variety of Earth applications, scientific, defense, and technological activities. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to Earth orbit of payloads and propulsive stages for higher altitude and planetary missions. The advent of readily available, economical transportation to and from low Earth orbit, for automated payloads, as well as for scientists and other personnel will revolutionize our concepts of using space and will expand the returns from space operations. The Shuttle's unique capabilities will not only lower the cost of space operations but will also lead to savings in the costs of payloads. These anticipated savings will result from repair and reuse of payloads and relaxation of weight and size constraints. The advantages offered by the Space Transportation System will enhance both the flexibility and the productivity of space missions compared to existing expendable launch vehicles.

Space Shuttle development is proceeding through a period of peak activity leading to initiation of orbital flight testing. Fabrication and test activities are intensifying in preparation for delivery of major flight hardware to Kennedy Space Center for the first orbital flight, which is now planned for late 1979.

The orbiter test vehicle--the Enterprise--has successfully completed the approach and landing test series and is currently at the Marshall Space Plight Center for full-scale ground vibration testing with an external tank and twin solid rocket boosters. Assembly and checkout of the first orbital flight vehicle are nearing completion consistent with delivery to the Kennedy Space Center in early 1979. This will support the start of orbital flight testing in late 1979. The orbiter structural test article has been completed and testing is in progress. After completion of these structural tests, it will be refurbished and equipped as the second orbital flight vehicle. Main engine and propulsion system testing is being conducted at the National Space Technology Laboratories, with approximately 35,000 seconds of test firings completed. The FY 1980 budget request provides for continuation of design, development, test, and evaluation activity on a schedule consistent with the major program milestones, including the planned first orbital flight in late 1979. A series of orbital flight test missions will follow. The FY 1980 program also provides for activities leading to a National fleet of four orbiter vehicles, which will include necessary modifications to the first two orbital flight vehicles and fabrication and assembly of two additional orbiters.

In summary, progress at this critical phase of the Shuttle development effort has been substantial, but has not sustained the pace necessary to accomplish the plan reflected in the original FY 1979 budget. Technical problems and increased requirements in contractor and subcontractor activities have made it necessary to adjust the program schedules and to request the supplemental appropriation in FY 1979. The FY 1980 budget request, which assumes the supplemental appropriation in FY 1979, provides for continuation of design, development, test and evaluation.

Progress on the Space Shuttle will be matched in other activities vital to the establishment of the Space Transportation System operational capability and to preparations for early operational missions. The Spacelab, which will be a multipurpose laboratory carried in the large cargo bay of the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the unique environment of space. The Spacelab is being designed and built by the European Space Agency, with ten European nations participating in this development. The Inertial Upper Stage (IUS), which is being developed by the Department of Defense, will be used to deploy Shuttle-launched payloads to high energy and escape orbits. The spinning solid upper stage is being developed commercially and will be used for payloads that do not require the IUS capability. Other space flight activities related to the Space Transportation System include ground support and control equipment, multiuse mission support equipment, training equipment, and long-lead time hardware procurement to provide external tanks and solid rocket boosters for early operational missions.

Space Transportation Systems activities during FY 1980 will also provide expendable launch vehicles and services, as well as engineering support, required during the transition to the Space Transportation System.

SPACE SCIENCE

The Space Science program utilizes space systems, supported by airborne and ground-based observations, to conduct scientific investigations of the Earth and its space environment, the Sun, the planets, and interplanetary and interstellar space, as well as the other stars of our galaxy and universe. The results from these investigations significantly contribute to our understanding of the universe, including the key questions of life, matter, and energy and the complex phenomena that have such a profound effect on life and environment on Earth.

The Sun exerts a primary influence on the Earth, and its immediate environment. A series of Orbiting Solar Observatory missions have been conducted to study solar phenomena. The discoveries from these missions and from the experiments flown during the Skylab Program provide the foundation for the Solar Maximum Mission to be launched in 1979. The Solar Maximum Mission spacecraft, together with data from Explorer spacecraft and Spacelab missions, will provide scientists with an opportunity to study the Sun, including solar flares and other phenomena, during the next period of peak solar activity in 1979-1981. The International Solar Polar Mission, a joint NASA and European Space Agency mission, will be launched in 1983 to study the polar regions of the Sun--regions which cannot be observed from the Earth or from current spacecraft. To achieve the trajectories required to study these polar regions, two spacecraft will be launched on a single Shuttle–IUS, will swing past Jupiter, and use the gravity of the giant planet to send one spacecraft toward the north pole of the Sun, and the other spacecraft toward the south pole. The measurements to be made are expected to yield previously unknown information about the Sun and its dynamics and to advance our understanding of the link between solar activity and weather and climate trends on Earth.

Development of the Space Telescope will continue to progress in FY 1980. This multiple purpose telescope will be launched by the Shuttle in 1983, and will serve as a highly versatile astronomy observatory in space for over a decade. The Space Telescope will greatly expand the volume of space accessible for observation, contributing significantly to our understanding of the origin and evolution of the universe and its energy–generating mechanisms.

Two of the three High Energy Astronomy Observatory missions have been successfully launched and are yielding important scientific information. The remaining mission is planned for launch in 1979. These missions are designed to explore the high energy phenomena observable with X–ray, gamma ray, and cosmic ray instruments. Work is also underway on Explorer spacecraft to study ultraviolet and infrared astronomy and the Sun–Earth relationships, and on payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab.

Orderly progress in the systematic exploration of the solar system is proceeding. Two Pioneer missions to Venus were launched in 1978. One of the missions is gathering scientific data while orbiting Venus; the other carried multiple probes to give us our first detailed measurements of the hot, dense atmosphere of Venus. One interesting discovery from the atmospheric probes is that Venus has an abundance of Argon and Neon, implying that the planet may have been formed from material fundamentally different from the material that formed the Earth.

Exploration of the outer planets is also progressing. The Pioneer 11 spacecraft is approaching its rendezvous with Saturn in 1979, and Pioneer 10 is on its way to being the first spacecraft to escape our solar system. Two Voyager spacecraft, launched in 1977, are speeding toward encounters with Jupiter in 1979 and with Saturn in 1980 and 1981. These spacecraft will make scientific measurements of the two giant planets and several of their satellites. Depending on the progress of the mission, one of these spacecraft may be targeted for an encounter with Uranus. Development work will be in progress on the Galileo mission, which will be launched in early 1982 and will conduct extensive exploration of Jupiter by sampling its atmosphere with an instrument-bearing probe, by obtaining scientific data on the planet's magnetosphere and atmosphere, and by observing its satellites.

A concentrated scientific effort is underway to analyze, and bring to bear on our understanding of the solar system, the wealth of data acquired from all relevant sources, including the planetary flight missions, the Helios solar missions, the lunar flight programs, ground–based observations, laboratory investigations, and lunar sample studies.

The Life Sciences research and development program is designed to provide a basis for enhancing people's ability to work efficiently in space; to develop experiments and related equipment to be flown on Spacelab missions; and to support NASA's research into the origin and chemical evolution of life. The knowledge gained from the Life Sciences program is made available to the scientific and technical community for application and advancement of medical research, education, and technology.

SPACE AND TERRESTRIAL APPLICATIONS

The objective of the Space Applications program is to develop, demonstrate and transfer space technology, systems and related capabilities which can be applied for practical benefits here on Earth. Space Applications research and development covers the areas of Resource Observations, Environmental Observations, Materials Processing and Communications. Technology Utilization activities are designed to accelerate and expand the availability and use of technology developed in all NASA programs into the private and public sectors of the economy.

In Resource Observations, identification and monitoring by means of remote sensing from space have demonstrated new capabilities to provide data useful in such areas as agricultural assessments, water resources management, coastal zone monitoring, improvement of maps, land use and surface mine monitoring, forestry and range resources inventory, and mineral and petroleum exploration. Remote sensing activities took an important step forward with the launch in March 1978 of Landsat-3, which extends the Landsat series with improved sensors and new capabilities to acquire data in the thermal region of the spectrum. Development will continue on Landsat-D, which will have a second generation, high-resolution remote sensing instrument--the thematic mapper--and the flight-proven multispectral scanner, leading to launch in 1981. The Landsat remote sensing capabilities are being supplemented by experimental use of data from the Heat Capacity Mapping Mission, launched in April 1978. Measurements from this satellite are being applied to thermal inertia mapping and rock-type identification, with the potential for substantial contributions in oil and mineral exploration as well as in siting major civil works. Joint activities with the users continue to demonstrate specific applications of the remote sensing data in a wide variety of areas.

In FY 1980, a joint effort in agriculture research will be initiated with the Department of Agriculture, the Department of Commerce, the Department of the Interior, and the Agency for International Development. This effort will emphasize the use of remote sensing data in concert with other data sources to improve our knowledge of domestic and foreign crop conditions and our commodity production estimates.

The launch of Magsat in late 1979 will apply remote sensing to magnetic field measurements. This satellite will provide data for use by the U.S. Geological Survey to update and improve worldwide magnetic anomaly maps. One application of these maps is in long-term planning of mineral and hydrocarbon exploration. Space capabilities are also used in the development of precise measurements of the movements of the Earth's crust and other dynamic characteristics of the Earth to support research in earthquake mechanisms. A joint effort with the

United States Geological Survey, National Science Foundation, National Geodetic Survey, the Department of Defense, and with other countries, will begin to monitor the motion and internal stability of several major tectonic plates and to determine the crustal deformation in seismically active areas.

In the area of Environmental Observations, NASA is involved with the National Oceanic and Atmospheric Administration and others in improving the understanding of atmosphere and ocean processes, providing space observations of parameters involved in these processes and extending the capabilities to predict environmental phenomena and their interaction with human activities.

Areas of research and development include upper atmospheric research; global weather prediction; severe storm research; climate research; environmental quality monitoring; and oceanic processes research. This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography. The program focuses on the special contributions space-derived data can make in these fields.

In 1978, NASA launched Nimbus-7, an experimental air and water pollution monitoring satellite; TIROS-N, the prototype for an advanced meteorological satellite system; and Seasat, an experimental satellite with significant capabilities for observing and monitoring ocean conditions. The stratospheric aerosol and gas experiment mission to measure atmospheric constituents is scheduled for launch in early 1979. During 1978 and 1979, NASA is participating in a major global atmospheric research program experiment.

NASA, in cooperation with other Federal agencies, is participating in a national program of climate research. In FY 1980, development will continue on the Earth Radiation Budget Experiment. This satellite system is designed to measure variations in the energy exchange between the Earth's atmosphere and space and other atmospheric factors important to climate research.

Research and development will also be pursued in environmental quality monitoring and in oceanographic areas related to the remote sensing capabilities of spaceborne systems. Work will be in progress in FY 1980 on atmospheric experiments to be conducted on Spacelab missions, including an Atmospheric Cloud Physics Laboratory to conduct research into very small scale atmospheric cloud processes.

Materials Processing research and development activities are designed to exploit the unique characteristics of the space environment to achieve results which are not possible or practical on Earth. Experiments are being conducted in laboratories and with sounding rockets to build on the results of tests conducted on previous space flights and to prepare for experiments to be conducted on future Spacelab missions. Development of equipment and experiments to be used on these missions will continue in FY 1980.

Communications research and development efforts concentrate on advanced technology for communications satellite systems with significantly improved capabilities and on providing technical support and consultation to other Government agencies. In FY 1980, NASA will begin focusing on the development of technology to increase the usable capacity of the radio frequency spectrum and of communications satellites in geosynchronous orbit, concentrating on the development of multibeam antennas and on-board switching techniques. Technical consultation activities include support of the Nation's participation in the World Administrative Radio Conference in 1979 which will reallocate worldwide usage of radio frequencies for communications activities. Development is proceeding on the search and rescue satellite system, a cooperative venture with other U.S. agencies, Canada, and France, to demonstrate improved capabilities for detecting and locating distress signals from aircraft and marine vessels.

Technology utilization activities are designed to accelerate the transfer to the nonaerospace industry, as well as State and local governments, of new knowledge and innovative technology generated by NASA and NASA contractors. During FY 1980, NASA will continue its efforts to assure effective and widespread dissemination of new technology through a variety of established mechanisms including publications, industrial applications centers, a computer software management and information center, State technology applications centers, special application teams, and applications engineering projects.

AERONAUTICS AND SPACE TECHNOLOGY

The objective of the Aeronautics program is the advancement of aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs. This technology is necessary to help maintain the competitive position of the United States in the international aviation marketplace and to aid the military in maintaining the superiority of the Nation's military aircraft.

Research and technology base activities concentrate on the disciplinary areas of materials, structures, propulsion, avionics, aerodynamics and human-vehicle interactions to provide advanced technology essential to meeting the future needs of civil aviation. A strong generic research and technology base is critical to continued growth and improvement in United States aeronautical capabilities. Emphasis will continue to be placed on developing the technology to improve performance, reduce energy requirements, enhance operating efficiency, reduce undesirable environmental effects, improve safety and reliability, and improve terminal area Operations for a variety of aircraft types. These efforts are integrated with additional focused technology efforts to develop advanced long haul and short haul air transportation system concepts,

In the area of conventional takeoff and landing aircraft, efforts will continue to focus on aircraft energy efficiency technology aimed at providing, in the 1980's, the technology advances that will lead to a major reduction in aircraft fuel requirements. Other technology activities will include work on reduction of aircraft noise and emissions and evaluation of the suitability of broad specification jet fuels for operation in current and next generation aircraft. Rotorcraft technology efforts will continue to emphasize rotor aerodynamics, structures, avionics, flight dynamics, terminal operations and drive systems and rotor system design. General aviation activities will focus on the reduction of noise and emissions, crashworthiness and advanced low cost avionics systems. Work on vertical takeoff and landing technology for potential future military and civil aircraft applications will be continued. Supersonic cruise research will focus on technology in the areas of propulsion, aerodynamics, structures, and controls. Research and technology efforts in the area of high performance aircraft will be conducted primarily in support of current and future military requirements.

The objectives of the Space Research and Technology program are to provide a technology base which will adequately support current and future space activities and to implement approaches for further reducing the costs of future space activities through improvement of components. The program provides a sound foundation of research and technology in the areas of materials, structures, sensing and detection, guidance and control, data reduction and distribution, chemical and electric propulsion, space energy systems and aerothermodynamics. Systems Studies will be pursued to investigate technology needs for future space missions. Systems Technology efforts in FY 1980 include continued work to develop and demonstrate the technology necessary to provide a data information and management system with an order of magnitude increase in efficiency and effectiveness from current systems. Systems Technology efforts will continue in key areas such as advanced communications, structures and materials, and propulsion.

The development and integration of experiments to be flown on early Shuttle and Spacelab missions will be continued. In 1980, experiments will be integrated into the Long Duration Exposure Facility which will be ready for integration with the Shuttle. In the Standards and Practices area, emphasis is being placed on completion of standard hardware for use on multiple missions, product improvement through component upgrading, and on improvement of program practices, concentrating on such areas as specifications, testing and flight project analysis.

Energy Technology efforts in NASA are primarily directed toward identifying the technology developed in the aeronautics and space program which has potential for making major contributions to the solution of energy problems on Earth. NASA provides technical support to the programs undertaken by other agencies to develop specific applications such as solar cells, solar heating and cooling, and electric power generation by wind power. NASA also makes its capabilities and facilities available to the Department of Energy and other agencies to accomplish energy technology activities on a reimbursable basis.

TRACKING AND DATA ACQUISITION

This program provides for continuation of tracking and data acquisition support for earth orbital spacecraft, planetary missions, sounding rockets, and research aircraft. This support is provided by a worldwide network of NASA ground stations, interconnected by a highly reliable communications system which provides the capability for instantaneous transmission of data and critical commands between spacecraft and the flight control centers. Facilities are also provided to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects.

The FY 1980 workload will remain high, with the Spaceflight Tracking and Data Network supporting an average of approximately 50 earth orbital scientific and applications spacecraft and the Deep Space Network supporting a full complement of planetary missions. Missions to be supported by the Spaceflight Tracking and Data Network include the High Energy Astronomical Observatories, the Heat Capacity Mapping Mission, Landsat-3, Nimbus-5, 6, and 7, International Sun-Earth Explorers, International Ultraviolet Explorer, as well as international missions and missions of other U.S. agencies. The Spaceflight Tracking and Data Network will also be supporting start of the Shuttle orbital flight tests. The support workload of the Deep Space Network will continue to include the Pioneer 6-11 missions, Helios 1 and 2 and Voyager 1 and 2 as well as Pioneer-Venus.

A major aspect of the Tracking and Data Acquisition program in future years will be the Tracking and Data Relay Satellite System (TDRSS), which will support essentially all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. NASA will acquire this capability through an arrangement under which the contractor will establish the system and provide NASA with TDRSS services beginning in 1981.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Federal Fundr

General and special fundr:

RESEARCH AND DEVELOPMENT*

*See Part III for additional information

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; tracking and data relay satellite services as authorized by law, and purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration, [$3,292,200,000] *$3,602,500,000*, to remain available unti! September 30, [1980] *1981*: *Provided, That contracts may be entered into under this appropriation for research and development activities to be continued thereafter* (42 U.S.C. 2451, et seq.; Deportment of Housing and Urban Development—Independent Agencies Appropriation Act, 1979, additional authorizing legislation to be proposed.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

Program and Financing (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1978 actual	1979 estimate	1980 estimate	1978 actual	1979 estimate	1980 estimate
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Space shuttle	1,349,200	1,443,300	1,366,000	1,401,475	1,408,700	1,393,500
(b) Space flight operations	267,800	309,700	467,300	256,983	306,900	445,000
(c) Expendable launch vehicle development and support	58,700	42,600	55,900	44,358	95,400	67,200
2. Scientific investigations in space:						
(a) Physics and astronomy	242,000	300,400	337,500	214,008	285,700	322,600
(b) Planetary exploration	159,500	182,400	220,200	160,382	182,000	214,500
(c) Life sciences	33,300	40,100	43,900	23,230	38,100	42,900
3. Space and terrestrial applications:						
(a) Space applications	280,500	286,200	347,100	262,421	284,900	329,000
(b) Technology utilization	9,100	9,100	12,100	7,390	10,100	11,600
4 Space research and technology	97,700	107,300	116,400	91,256	109,400	112,400
5. Aeronautical research and technology	228,000	264,100	300,300	211,137	244,000	273,100
6. Energy technology	7,500	5,000	3,000	6,457	5,700	4,000
7 Supporting activity:						
(a) Tracking and data acquisition	278,300	302,000	332,800	276,711	301,100	323,000
Total direct program	3,011,600	3,292,200	3,602,500	2,955,808	3,272,000	3,538,800
Reimbursable program:						
1. Space transportation systems:						
(a) Space shuttle	22,306	34,594	32,642	12,067	29,860	29,720
(b) Space flight operations	18,943	63,574	79,778	14,693	61,710	77,440
2. Scientific investigations in space:						
(a) Physics and astronomy	3,709	600	600	1,238	3,440	720
(c) Life sciences	433	419	408	314	470	410
3. Space and terrestrial applications:						
(a) Space applications	170,539	220,973	140,582	156,543	217,890	153,830
(b) Technology utilization	8,328	7,293	7,293	6,137	8,020	7,330
4. Space research and technology	2,646			2,084	1,170	280
5 Aeronautical research and technology	18,714	16,692	12,767	15,417	18,240	13,640
6. Energy technology	110,601	158,400	196,900	102,712	161,830	187,750
7. Supporting activity:						
(a) Tracking and data acquisition	4,213	3,655	4,130	3,565	3,570	3,980
Total reimbursable program	360,432	506,200	475,100	314,770	506.200	475,100
Total program costs, funded	3,372,032	3,798,400	4,077,600	3,270,578	3,778,200	4,013,900
Change in selected resources (undelivered orders and stores)				39,745	377,548	63,700
10.00 **Total**	3,372,032	3,798,400	4,077,600	3,310,323	4,155,748	4,077,600

RESEARCH AND DEVELOPMENT—Continued

Program and Financing (in thousands of dollars)—Continued

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programed) 1978 actual	1979 estimate	1980 estimate	Costs and obligations 1978 actual	1979 estimate	1980 estimate
Financing:						
Offsetting collections from:						
11.00 Federal funds	–243,933	–313,184	–354,740	–243,933	–313,184	–354,740
14.00 Non-Federal sources	–116,499	–193,016	–120,360	–116,499	–193,016	–120,360
21.40 Unobligated balance available, start of year: For completion of prior year budget plans:						
Direct				–190,484	–240,403	
Reimbursable				–105,155	–116,945	
24.40 Unobligated balance available, end of year: For completion of prior year budgel plans:						
Direct				240,403		
Reimbursable				116,945		
Budget authority	**3,011,600**	3,292,200	**3,602,500**	**3,011,600**	**3,292,200**	**3,602,500**
Budget authority:						
40.00 Appropriation	3,013,000	3,292,200	3,602,500	3,013,000	3,292,200	3,602,500
41.00 Translerred to other accounts	–1,400			–1,400		
43.00 **Appropriation (adjusted)'**	**3,011,600**	3,292,200	**3,602,500**	**3,011,600**	3,292,200	**3,602,500**
Relation of obligations to outlays:						
71.00 Obligations incurred, net				2,949,890	3,649,548	3,602,500
72.40 Obligated balance, start of year				554,672	515,865	1,016,913
74.40 Obligated balance, end of year				–515,865	–1,016,913	–1,165,513
90.00 Outlays				2,988,697	3,148,500	3,453,900

Note.—Reconciliation of budget plan to obligations

	1978 actual	*1979 estimate*	*1980 estimate*
Total budgel plan	3,372,032	3 798,400	4,077,600
Deduct portion of budgel plan lo be obligated in subsequent years	234,304		
Add obligations of prior year budgel plans	172.595	357.348	
Total obligations	3,310,323	4,155,748	4,077,600

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

BUDGET PLAN SUMMARY

Code		FY 1978	FY 1979	FY 1980
		(Thousands of Dollars)		
	SPACE TRANSPORTATION SYSTEMS	1,751,500	2,009,500*	1,904,000
253	Space shuttle	1,349,200	1,628,300*	1,366,000
253	Space flight operations	267,800	309,700	467,300
253	Expendable launch vehicles	134,500	71,500	70,700
	SPACE SCIENCE	404,700	505,400	601,600
254	Physics and astronomy	224,200	282,900	337,500
254	Planetary exploration	147,200	182,400	220,200
254	Life sciences	33,300	40,100	43,900
	SPACE AND TERRESTRIAL APPLICATIONS	243,900	283,900	344,400
254	Space applications	234,800	274,800	332,300
254	Technology utilization	9,100	9,100	12,100
	AERONAUTICS AND SPACE TECHNOLOGY	333,200	376,400	419,700
405	Aeronautical research and technology	228,000	264,100	300,300
254	Space research and technology	97,700	107,300	116,400
254	Energy technology	7,500	5,000	3,000
255	TRACKING AND DATA ACQUISITION	278,300	302,000	332,800
	TOTAL	3,011,600	3,477,200"	3,602,500

*Includes proposed supplemental appropriation of $185,000,000 for Space Shuttle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code		FY 1978	FY 1979	FY 1980
		(Thousands of Dollars)		
253	Space Flight	1,751,500	2,009,500*	1,904,000
254	Space Science, Applications and Technology	753,800	901,600	1,065,400
255	Supporting Space Activities	278,300	302,000	332,800
(250)	Subtotal, General Science, Space and Technology	2,783,600	3,213,100*	3,302,200
402	Air Transportation	228,000	264,100	300,300
	Total	3,011,600	3,477,200*	3,602,500

"Includes proposed supplemental of $185,000,000 for Space Shuttle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR
(Thousands of Dollars)

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Flight Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
OFFICE OF SPACE TRANSPORTATION SYSTEMS, TOTAL	1978	1,751,500	913.647	169,312	511,067	16,100	66,734	475	---	470	760	16,276	38,903	17.756
	1979	2,009,500	1,088,916	224.393	585,607	16,292	37,150	---	---	10	1,035	11,433	16,322	28,342
	1980	1,904,000	1,031,900	200,300	567,750	9,500	47,100	---	---	---	1,500	7.300	16,400	22.250
Space shuttle	1978	1,349,200	788,743	104.012	433,688	10,000	---	---	---	345	760	126	500	11,026
	1979	*1,628,300	944,396	158.600	499,400	10,200	---	---	---	10	1.035	93	500	14,066
	1980	1,366,000	861,100	124,800	359,300	4,000	---	---	---	---	1,500	100	---	15,200
Space flight operations	1978	267,800	124,904	54,065	77,379	6,100	2,116	475	---	125	---	50	200	2,386
	1979	309,700	144.520	56,133	86,207	6.092	3,465	---	---	---	---	---	---	13,283
	1980	467,300	170,800	71,700	208.450	5,500	6.700	---	---	---	---	---	---	4,150
Expendable launch vehicles	1978	134,500	---	11,235	---	---	64,618	---	---	---	---	16,100	38,203	4,344
	1979	71,500	---	9,660	---	---	33,685	---	---	---	---	11,340	15,822	993
	1980	70,700	---	3,800	---	---	40,400	---	---	---	---	7,200	16,400	2,900
OFFICE OF SPACE SCIENCE, TOTAL	1978	404.700	22,016	92	85,473	50	88,631	85,261	6,118	55,317	140	12,498	874	48,230
	1979	505,400	20,776	400	127,616	---	86,736	136,597	6,614	62,160	185	1,150	200	62,966
	1980	601,600	23,246	650	158,122	---	80,793	196,733	5,219	67,157	200	855	---	68,625
Physics and astronomy	1978	224,200	275	---	85,394	---	85,590	9.583	6,118	15,477	---	1,498	738	19,527
	1979	282,900	220	---	125,128	---	83,377	27,212	6,614	7,238	---	1,150	200	31,761
	1980	337,500	216	---	158,112	---	76,963	58.353	5,219	4.157	---	855	---	33.625
Planetary exploration	1978	147,200	8,717	---	79	---	3,041	74,100	---	27.288	---	11,000	80	22,895
	1979	182,400	4,356	---	2.488	---	3,359	107,675	---	38,805	---	---	---	25,717
	1980	220,200	6,380	---	10	---	3,830	136,330	---	44.520	---	---	---	29,130
Life sciences	1978	33,300	13,024	92	---	50	---	1.578	---	12,552	140	---	56	5,808
	1979	40,100	16,200	400	---	---	---	1.710	---	16,117	185	---	---	5,488
	1980	43,900	16.650	650	---	---	---	2,050	---	18,480	200	---	---	5,870
OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS, TOTAL	1978	243,900	27.306	730	17,314	3,890	127,363	29.132	3,543	7,048	67	9,903	3,286	14,318
	1979	283,900	24,507	793	27,988	2,955	157,255	23,089	2,956	6.880	54	13,072	4,063	20,288
	1980	344,400	31,350	975	30,025	3,800	185,000	24.000	4,325	11,550	60	20,125	5,525	27,665
Space applications	1978	234,800	27,206	535	16,679	3,890	126,683	28,593	3,533	6,191	---	9,035	3,030	9.425
	1979	274,800	24,347	703	27,506	2,955	156,398	22,612	2,952	6,285	---	12.134	3,735	15.173
	1980	332,300	31,150	825	29,525	3,750	184,100	22,300	4,125	10,550	---	19,125	5.125	21,725
Technology utilization	1978	9,100	100	195	635	---	680	539	10	857	67	868	256	4,893
	1979	9,100	160	90	482	---	857	477	4	595	54	938	328	5.115
	1980	12,100	200	150	500	50	900	1,700	200	1,000	60	1,000	400	5,940
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1978	333,200	6,074	---	8,767	---	5,303	26,877	953	49,803	14,463	119,994	91.487	9,479
	1979	376,400	7,146	---	11,259	---	7,539	27,528	619	59,319	9,047	119,248	128.187	6,508
	1980	419,700	10,140	---	8,250	---	9,300	26,750	700	61,740	13,400	142,700	139.520	7,200
Aeronautical resear& and technology	1978	228,000	700	---	756	---	---	1,275	953	41,100	14,423	94,862	71,050	2,881
	1979	264,100	1,245	---	958	---	---	1,310	619	49,312	9,047	93,961	104,452	3.196
	1980	300,300	700	---	900	---	---	1,100	700	51,900	13,400	115,300	113.000	3,300
Space research and technology	1978	97,700	4,499	---	6,846	---	5,303	24,051	---	8,563	40	25,132	19,028	4.238
	1979	107,300	5,001	---	8,801	---	7,539	25,018	---	10,007	---	25,287	22,335	3,312
	1980	116,400	9.440	---	6,500	---	9,300	24,600	---	9,840	---	27,400	25.420	3,900
Energy technology	1978	7,500	875	---	1,165	---	---	1,551	---	140	---	---	1,409	2,360
	1979	5,000	900	---	1,500	---	---	1,200	---	---	---	---	1,400	---
	1980	3.000	---	---	850	---	---	1,050	---	---	---	---	1,100	---
OFFICE OF SPACE 'CRACKING AND DATA SYSTEMS	1978	278,300	---	---	---	---	199,211	57,626	5,444	---	3,154	---	---	12,865
	1979	302,000	---	---	---	---	216,200	61.300	5,900	---	3,300	---	---	15.300
	1980	332,800	---	---	---	---	238,200	68,800	6,300	---	3,000	---	---	16,500
TOTAL BUDGET PLAN	1978	3,011,600	969,043	170,134	622.621	20,040	487.242	199,371	16,058	112,638	18,584	158,671	134,550	102,648
	1979	3,477,200	1,141,345	225,586	752.470	19,247	504,880	248,514	16,089	128,369	13,621	144,903	148,772	133,404
	1980	3,602,500	1,096,636	201,925	764,147	13,300	560.393	316,283	16,544	140,447	18,160	170,980	161,445	142,240

*Includes supplemental request of $185 million.

SPACE
TRANSPORTATION
SYSTEMS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE TRANSPORTATION SYSTEMS

Programs	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space Shuttle	1,349,200	1,439,300	1,628,300*	1,366,000
Space flight operations	267,800	311,900	309,700	467,300
Expendable launch vehicles	134,500	76,500	71,500	70,700
Total	1,751,500	1,827,700	2,009,500*	1,904,000

*Includes proposed supplemental request of $185,000,000.

SPACE
SHUTTLE

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS

SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Design. Development. Test and Evaluation..........	1.307.500	985.300	1.170.300*	610.500	
Orbiter..	813.060	536.500	654.900	283.400	1-6
Main engine....................................	197.400	176.700	161.400	110.600	1-9
External tank..................................	88.030	80.500	107.600	59.800	1-11
Solid rocket booster...........................	104.998	63.500	100.200	57.500	1-12
Launch and landing.............................	104.012	128.100	146.200	99.200	1-14
Production.....................................	41.700	454.000	458.000	755.500	
Orbiter..	29.140	397.000	344.100	590.600	1-18
Main engine....................................	12.560	18.000	81.300	80.300	1-19
Launch and landing.............................	---	11.000	12.400	24.600	1-19
Spares and equipment...........................	---	28.000	20.200	60.000	1-19
Total..	1.349.200	1.439.300	1.628.300*	1.366.000	

*Includes Supplemental request of $185.000.000.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Distribution of Program Amount by Installation:				
Johnson Space Center	788,743	917,900	944,396	861,100
Kennedy Space center	104,012	140,200	158,600	124,800
Marshall Space Flight Center	433,688	361,800	499,400	359,300
National Space Technology Laboratories	10,000	5,100	10,200	4,000
Ames Research Center	345	100	10	---
Dryden Flight Research Center	760	800	1,035	1,500
Langley Research Center	126	100	93	100
Lewis Research Center	500	---	500	---
Headquarters	11,026	13,300	14,066	15,200
Total	1,349,200	1,439,300	1,628,300	1,366,000

OFFICE OF SPACE TRANSPORTATION SYSTEMS | SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle is the key element of a versatile, economical space transportation system that will provide a wide variety of national and international users with round trip access to space beginning in the 1980's. The Shuttle will be the first reusable space vehicle and will be configured to carry many different types of payloads to and from low Earth orbit. Its development will provide multipurpose, economical space operations for earth applications, scientific, defense and technological payloads. The Shuttle is, however, much more than just a transportation vehicle. It will offer unique capabilities that cannot be achieved with today's expendable lsunch vehicles--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions. These capabilities will greatly enhance the flexibility and productivity and result in savings in the cost of space operations.

The Space Shuttle consists of four basic flight hardware elements--the orbiter, the main engines, an external propellant tank and twin solid rocket boosters--plus launch and landing systems. The orbiter is the reusable spacecraft portion of the Space Shuttle. Its large payload volume of 285 cubic meters (370 cubic yards) and cargo carrying capacity of up to 29,500 kilograms (65,000 pounds) will permit payloads to be built to less restrictive design requirements. The orbiter vehicle will carry personnel and payloads to orbit to perform their assigned tasks and return them to Earth. The orbiter is roughly the size of a DC-9 aircraft and contains three liquid fueled reusable main engines. It can provide a habitable environment for the crew, which will include scientists and engineers, for missions up to thirty days in duration.

MISSION PROFILE:

The Space Shuttle will be launched into space by the thrust of its three liquid oxygen/liquid hydrogen main engines, burning in parallel with the twin solid rocket boosters. Two minutes into the flight, at an altitude of about 45 kilometers (km) (24 nautical miles), the solid rocket boosters will burn out, separate, and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) down range. They will then be recovered for refurbishment and reuse. The orbiter will continue on into space, powered by its three main engines, for another six and one-half minutes. Just before orbital insertion, the engines will be shut down and the external tank will be jettisoned. Following a ballistic trajectory, the empty tank will reenter, tumble and break up over a remote ocean area about 18,500 km (10,000 nautical miles) down range. The orbiter, aided by its orbital maneuvering engines, will enter earth orbit to perform its mission. After completing the mission, the orbiter will again fire its orbital maneuvering engines to deorbit and reenter the atmosphere for its approach and landing.

The Space Shuttle will have a crew of three: the commander, the pilot, and a mission specialist. On some missions, up to 4 more mission or payload specialists may be added. The crew will experience forces no greater than three times that of gravity (3-g forces) during launch and landing and will be able to perform their work in a shirt-sleeve environment.

STATUS:

Space Shuttle development is in a period of peak effort and well on its way to the first orbital flight planned for late 1979. All major Shuttle system elements are proceeding in test and manufacture and all major ground test programs are now being conducted. The test elements for the Mated Vertical Ground Vibration Test (MVGVT) have been delivered to the Marshall Space Flight Center (MSFC) and testing is now in progress. This MVGVT program will verify the vibration characteristics during liftoff and at other times during the ascent profile. The tests will be completed in early 1979. The Main Propulsion Test (MPT) series started in 1978 at the National Space Technology Laboratories (NSTL) and will continue through 1979. This includes three main engines mounted on an orbiter aft fuselage and an external tank.

FY 1979 activities support preparations for the first orbital flight planned in late 1979. The Orbiter 102, which will be used for the orbital flight tests, is in final assembly and checkout at Palmdale, California. In early 1979, this orbiter will be delivered to KSC where it will begin preparations for launch. The orbiter structural test article was completed by Rockwell International and transferred to the Lockheed plant in Palmdale for structural testing, which started in 1978 and is scheduled for completion in mid-1979. Engine testing has been temporarily suspended because of an engine failure which essentially destroyed an engine. Testing will be resumed after the ongoing modifications are completed. Prior to this incident, engine testing was proceeding at a good pace, with over 5,000 seconds accumulated on one flight configured engine. The first set of flight engines will be acceptance tested at NSTL in Mississippi and, together with associated ground support equipment, will be delivered to KSC for installation on Orbiter 102 in 1979.

Fabrication of three external tank test articles has been completed, and they are being used for structural, vibration, and main propulsion testing. The second and third solid rocket motor development firings were accomplished during 1978, and the fourth and final development firing is planned for early 1979. In addition, the first solid rocket booster components for the first orbital flight were delivered to KSC during 1978.

The computerized launch processing system (LPS) at KSC in Florida, as well as the ground support equipment at KSC and at the Dryden Flight Research Center in California, are in the final stages of completion, and software validation is underway. LPS hardware deliveries have been completed, simulation support is continuing for development of checkout procedures, and checkout software is being developed. Integration of all the ground support equipment will continue and flight equipment will be checked out and processed after it arrives at KSC for launch.

To establish a national fleet of operational orbiters, Shuttle production includes fabrication of two additional orbiters, refurbishment of Orbiter 102 after its use in the orbital flight tests and early operations, and conversion of the structural test article (STA) to an operational orbiter (099). Also included are the second series of launch and ground support equipment at KSC for the simultaneous launch processing of two orbiters, and initial operational spares and equipment. Activities planned in FY 1979 include long lead orbiter subsystem hardware fabrication for converting the STA to orbital flight capability, and the start of primary structures fabrication for Orbiter 103. In addition, main engine hardware fabrication will take place and procurement of ground support equipment required for the "second line" launch capability at KSC will be initiated.

In August 1978, a detailed Space Shuttle program review was held to assess the cost, schedule and performance status. Although substantial progress has been made during this past year, the review substantiated the need to reschedule the first manned orbital flight to late 1979 and identified the requirement for additional funding in FY 1979. Testing and correction of technical problems, increased work required, mandatory changes, and necessary weight reductions have all contributed to the delay and the need for additional funds. The FY 1980 budget request is based on availability of these additional funds in FY 1979.

MAJOR PROGRAM ACTIVITIES PLANNED IN FY 1980:

- Complete main propulsion testing to support performance requirements
- Deliver the second set of main engines to KSC
- Complete delivery of four flight sets of solid rocket booster hardware for the orbital flight test (OFT) program
- Complete delivery of four external tanks for the OFT program
- Conduct the first manned orbital flight (STS-1) and continue with subsequent OFT flights
- Process development hardware for flights Nos. 2, 3, and 4
- Continue production leading to a national fleet of operational orbiters

CHANGES FROM FY 1979 ESTIMATE:

NASA is requesting a supplemental appropriation of $185 million to meet additional Shuttle development requirements in FY 1979. These requirements are a result of additional efforts necessary to solve technical problems identified in FY 1978. These include the need for expanded testing activities, schedule delays, and in general, a need for more work than was previously planned, particularly in the engineering required for systems qualification and certification and the manufacturing efforts to fabricate flight and test hardware. The FY 1980 budget request assumes approval of the proposed FY 1979 supplemental appropriation.

DESIGN, DEVELOPMENT, TEST AND EVALUATION

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Orbiter..................	813,060	536,500	654,900	283,400

OBJECTIVES AND STATUS:

The Space Shuttle orbiter is a reusable vehicle which serves as the orbiting spacecraft to deploy and retrieve payloads and to provide quarters for the personnel, and which reenters the atmosphere and lands as an unpowered aircraft, returning crew and payloads to the launch site. A payload of 29,500 kilograms (65,000 lbs.) can be placed in low Earth orbit at an altitude of 185 km (100 n.m.). The physical dimensions of the payload may be as large as 4.6 meters (15 ft) in diameter and 18.3 meters (60 ft) in length.

The testing required to certify Orbiter 102 for the first flight test is planned to be completed by mid-1979. The approach and landing tests with the Orbiter 101 test vehicle have been successfully completed and the objectives achieved. This orbiter is now being used in the full-scale ground vibration tests at MSFC. Assembly will be completed on Orbiter 102, which will then undergo final factory checkout and be shipped to KSC via the 747 carrier aircraft early in 1979. It will then enter the prelaunch checkout phase. During this phase, it will be stacked and checked out in support of the planned first Shuttle launch from KSC in late 1979.

The structural test article, which has a flight-type orbiter airframe, was transferred to the Lockheed test facility at Palmdale, California, in early 1978. This test article, which includes a mass to simulate the crew module, is undergoing static load testing. These tests are scheduled for completion in mid-1979, after which the STA will be converted to an orbital vehicle (099). Satisfactory completion of structural testing is required for flight loads certification of Orbiter 102.

The orbiter main propulsion test article (MPTA) was installed in the test stand at NSTL and test firings started in 1978. Testing of the three main engines, using the MPTA and an external tank, to acquire propulsion system performance data as well as acoustic data, will continue through 1979.

During 1978, a method was implemented for installing thermal protection system (TPS) tiles on the orbiter which assured maintaining the stringent step, height and gap tolerances. Problems during 1978 included difficulties in developing workforce size and skills and producing tiles with complex shapes. These problems have hampered progress, but work has been scheduled at both the Palmdale assembly plant and at KSC to support the planned first launch in 1979. Certification testing and analysis to support the first orbital flight will be completed and flight testing will then allow definition of actual margins in the TPS system for follow-on flights.

Early orbital flight software is being used to conduct orbital flight verification tests. Initial checkout of the Palmdale and KSC test procedures, detailed evaluations of the flight control interaction with the dynamic model interfaces, and study of the remote manipulator system avionics interactions will be performed at the Shuttle Avionics Integration Laboratory (SAIL). Facility acceptance tests of the SAIL at the Johnson Space Center (JSC) with the MSFC Mated Elements System will be completed in mid-1979. This will assure that the facilities are ready to start verification of the complete avionics system and its interfaces with the Shuttle vehicle. Acceptance test of the Flight Systems Laboratory (including the Avionics Development Laboratory, Flight Control Hydraulics Laboratory, crew station, and backup flight control system flight software verifications facility) at Rockwell in Downey, California, will also be completed.

Support activities managed by JSC, including modifications to the Mission Control Center, use of crew training simulators, development of Government-furnished equipment such as space suits, and the performance of tests to support the orbiter project, will all continue. The emphasis for FY 1979 is on preparation for the orbital flight tests.

The emphasis during FY 1979 in the remote manipulator system (RMS) is the completion of operating techniques to handle payloads and the training of RMS operators. Selective simulations are being conducted to evaluate and analyze RMS operational and payload performance. Efforts are being focused on procedures for ground handling operations, RMS installation into the orbiter, and system checkout. The Canadian-funded effort will support the manufacture and integrated testing of the RMS flight hardware for the orbiter, the completion of the qualification testing, and the delivery of the first flight unit to KSC in late 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 orbiter estimate has increased by $118.4 million. This increase resulted from additional engineering activity due to extended qualification and certification test programs, technical problems encountered on Orbiter 102, and a continuing high level of change activity. Manufacturing hours to complete the assembly and checkout of Orbiter 102 have also increased. In addition, there have been funding increases in a number of subcontracts due to development and producibility problems. Examples include thermal protection, reaction control, auxiliary power unit, and Ku-Band rendezvous radar. Other funding increases have been experienced in the orbiter support activities caused by schedule delays, and in the systems area due to necessary additional vehicle system testing planned for FY 1979.

BASIS OF FY 1980 ESTIMATE:

The orbital flight test effort, using Orbiter 102, is planned for initiation in late 1979 with the first manned orbital flight (STS-1). Analysis of this first OFT will be conducted and engineering will be provided to support follow-on development flights. During 1980, orbital flights are planned on an average of every three to four months.

Each development flight is a test to progressively support the verification of the Space Shuttle for operational use. Design certification and flight readiness reviews will be conducted before each flight to assure that there are no constraints to the specified flight mission assignment. The orbital tests are necessary to verify hardware and software operation, ground and flight procedures, system characteristics over a range of conditions, primary and backup operational modes, and overall performance. Flight test data on the systems performance will be reviewed after each flight and corrective action taken where necessary to meet operational requirements. Throughout the OFT program, engineering will be provided to perform this analysis, resolve problems and verify systems operations. These FY 1980 efforts will lead to the certification of the Space Shuttle's readiness to enter the operational phase in 1981.

After the first orbital flight, the avionics configuration verification testing will be conducted at the Shuttle Avionics Integration Laboratory and the Electronic Systems Test Laboratory with flight software programs, the remote manipulator control systems, the Ku-Band tracking radar, communications interfaces with Tracking and Data Relay Satellite System, and the S-Band payload systems interfaces. In addition, software maintenance and updating to incorporate mission-unique changes will continue throughout FY 1980. During FY 1980, the development of the remote manipulator system will be completed, and it will be flight tested during the OFT program. Post-flight analyses will also be performed.

The support activities necessary for each OFT will continue in FY 1980. The Mission Control Center will support integrated simulations with the Shuttle Mission Simulator to train the flight crews and flight controllers for these orbital flights.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- Conduct orbiter analysis of the first orbital flight test (STS-1)
- Complete certification of Orbiter 102 flight readiness for the follow-on orbital flight tests
- Deliver OFT mission kits
- Continue life demonstration tests on critical orbiter subsystems
- Support OFT flights 2-4 in preparation, data analysis, and engineering and incorporation of necessary changes.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Main Engine...	197,400	176,700	161,400	110,600

OBJECTIVES AND STATUS:

The Space Shuttle orbiter will use three high pressure liquid hydrogen/oxygen engines, each with a 2,100,000 newton (470,000 pound) vacuum thrust level. The Space Shuttle Main Engine (SSME) represents a major advance in propulsion technology and incorporates maximum utilization of existing technologies. In addition, it has the advantage of a long operating life. It will be the first large liquid fuel rocket engine designed to be reusable, and will require minimum maintenance between flights. An engine-mounted controller will be used to ensure operation within the limits of the high temperatures and pressures in the combustion cycle. Performance will be increased by using a two-stage combustion process with a high expansion ratio nozzle, which results in more efficient engine operations.

During FY 1978, problems were experienced with a number of engine components, which caused the main engine project to fall behind in accumulated engine test time. Investigation of these problems has identified failure modes and causes, and modifications are being tested. As a result, engine testing was proceeding at a good pace until a recent (December 27, 1978) failure, which destroyed most of the internal parts of an engine (2001) undergoing acceptance testing. This caused a temporary suspension of the testing. The cause of the failure has been determined and modifications are now being made to correct this problem, leading to resumption of testing in late January. Another engine is being assigned to the main propulsion test program.

Engine testing is still a pacing item to perform STS-1 in 1979. However, progress on the main engine development since the summer of 1978 has been significant. A total of 6,600 seconds at the rated power level (RPL) of 100% was achieved in one month, with over 5,000 seconds on one flight configured engine including six tests at RPL, each for the full mission duration of 520 seconds. A total of about 400 tests have been conducted accumulating almost 35,000 seconds of operation, with about 75 tests and 11,000 seconds at RPL. In addition to the two existing test stands at NSTL, an engine test stand has been activated at Santa Susana in California.

Testing will continue on flight configured engines during 1979, leading to the main engine flight certification for STS-1. The main propulsion test article, consisting of a cluster of three engines, a flight weight external tank and the aft fuselage of the orbiter, will also continue in testing during the fiscal year, and these engines will be maintained in the latest configuration. Data from main propulsion testing will constitute a part of the engine verification. Single engine testing will also be intensive in order to prove the durability of each element of the system. Rigorous examination of each hardware component will be accomplished as a part of this thorough test activity. In 1979, the first set of three flight engines and one spare will be delivered to KSC.

In addition to the development and test work by Rocketdyne and the subcontractors, the main engine activities provide the necessary project support efforts. These efforts include the procurement of propellants for test firing the engine and its components, the maintenance of the engine systems hardware simulation laboratory, logistics support, and the evaluation of materials and processes.

By mid-1979, all necessary ground support equipment will be delivered to KSC to support installation of the first flight engines.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The main engine development estimate for FY 1979 has decreased by $15.3 million. Main engines for Orbiter 099 have been allocated to production consistent with the conversion of the orbiter structural test article (OV-099) to flight status in the production phase. This change was partially offset by development increases caused by addition of a third test stand capability to enhance development progress and some deferral of work necessitated by analysis and resolution of engine test problems.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, continuing support will be provided for the orbital flight tests. This effort will include a full complement of component and full engine test capability and analytical support for the flight conditions. Fabrication, acceptance testing, and delivery of additional development test engines will be completed. Full engine testing will continue in order to meet operational power and engine life requirements. This activity includes final flight certification of the engine. During the certification program, the engine must demonstrate reliability and performance at 109% (full rated power level), and a life requirement of 3 1/2 hours and 55 starts.

The last two main propulsion test article tests are scheduled for FY 1980 to demonstrate 109% power level operation of three engines in a cluster. FY 1980 main engine funding will also support the engine systems simulation laboratory, engine software integration, and procurement of propellants for the test programs at Santa Susana and NSTL.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- Continue full engine testing to achieve final flight certification and extended life demonstration
- Complete fabrication and delivery of development test engines

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
External Tank (ET)	88,030	80,500	107,600	59,800

OBJECTIVES AND STATUS:

The External Tank (ET) will contain all the propellants for the orbiter's three main engines--liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The liquid propellants are consumed by the orbiter's main engines from liftoff to main engine cutoff, which occurs just before the orbital insertion. Following the main engine cutoff, the ET will separate from the orbiter and tumble through a ballistic trajectory to break up over a designated remote ocean area. The ET is a single assembly approximately 8.5 meters (27.5 feet) in diameter, and 47 meters (154 feet) long. It will contain approximately 700,000 kilograms (1.55 million pounds) of propellant at liftoff. The liquid hydrogen volume is 1,530 cubic meters (54,000 cubic feet) and the liquid oxygen volume is approximately 565 cubic meters (20,000 cubic feet).

The ET is the only expendable element in the Space Shuttle system and every effort is being made to keep the unit cost to a minimum. The prime contractor's design has emphasized commonality of configuration between the tank elements in order to utilize the same tooling for the oxygen and hydrogen tanks where feasible. Six large tools are common to the fabrication of domes and barrel sections for both of the propellant tanks. Extremely lightweight, nominal one-inch thick, spray-on foam insulation will be applied to the outer surface of the external tank. Thermal ablative coating will be applied to high heat load surfaces.

Early in FY 1979, structural testing of the liquid hydrogen test tank was initiated at MSFC. This activity will be completed in 1979, along with the already started oxygen tank structural verification tests.

During the first quarter of FY 1979, the main propulsion test tank was upgraded at NSTL to a full flight configuration. A complete test tank is also being used in the full scale ground vibration tests, together with the Orbiter "Enterprise" and solid rocket boosters. This testing is planned for completion in early 1979.

Four flight tanks are currently in various stages of assembly and checkout at the Michoud Assembly Facility (MAF) in Louisiana. Improvements in some manufacturing techniques were required, particularly with regard to the application of thermal protection materials. Some fabrication delays were encountered, and delivery of the first flight tank to KSC is now expected in the first half of 1979 to support the planned STS-1 launch. After arrival at KSC, final installations of equipment and systems checkout will take place. Completion of the ET thermal protection system application will precede the assembly of the tank into the Space Shuttle vehicle at KSC. Fabrication of the final two DDT&E flight external tanks will be initiated during FY 1979, and a second flight tank is expected to be delivered to KSC by the end of the fiscal year.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The external tank estimate for FY 1979 has increased by $27.1 million. The increase has been caused by changes due to loads and thermal analyses from wind tunnel test updates affecting structural loads and ascent heating requirements. In addition, hardware delivery delays resulted from difficulties in applying the thermal protection system to the flight tanks.

BASIS OF FY 1980 ESTIMATE:

The third and fourth development test tanks will be in the final phase of assembly and checkout at MAF and delivery is planned during the first two quarters of FY 1980. The final two development test external tanks (Nos. 5 and 6) will be in the major welding assembly tool during early FY 1980 and will phase through the thermal protection systems assembly positions, mating operations and proceed through final checkout. Delivery of these last two DDT&E tanks is planned for the second half of FY 1980.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- Delivery of DDT&E External Tanks 3, 4, 5 and 6
- Complete final ET installations at KSC for STS - 2, 3, 4 and 5

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Solid Rocket Booster (SRB)	104,998	63,500	100,200	57,500

OBJECTIVES AND STATUS:

The Space Shuttle propulsion system includes two reusable solid rocket boosters which burn in parallel with the orbiter main engines to provide the necessary thrust from liftoff to booster staging. Each SRB weighs approximately 583,600 kilograms (1.29 million pounds) and delivers approximately 11.6 million newtons (2.6 million pounds) average vacuum thrust. These boosters are approximately 3.6 meters (12.2 feet) in diameter and 45.5 meters (149 feet) long and are attached to the ET. After burnout, at an altitude of about 45 kilometers (150,000 feet), they separate from the ET. The SRBs will descend by parachute and land in the ocean about 260 kilometers (140 nautical miles) from the launch site. They will be recovered by ship and returned for refurbishment and reuse.

The main element in the solid rocket booster system is the solid rocket motor (SRM), which is being developed by Thiokol, Wasatch Division, Utah. The other booster system elements such as the recovery system, thrust vector control, attach structures, forward and aft skirt, and separation motors are being procured separately. MSFC will perform designated systems integration tasks and has the responsibility for total systems integration of the solid rocket booster effort.

In 1978, the parachute drop test program consisting of six drop tests, was successfully completed. Qualification test firings of the booster separation motors occurred during 1978 and that test program is scheduled for completion early in 1979.

The electrical and instrumentation test program was completed in FY 1978 and manufacture of flight systems is proceeding. Verification testing of the thrust vector control system will continue into early 1979.

The SRB structural test program was initiated at MSFC and testing will continue in 1979. The SRB hardware required for the mated vehicle ground vibration test was also delivered to MSFC in 1978.

In addition to conducting qualification and verification testing, in mid-1979, the booster assembly contrator, United Space Boosters, Incorporated, will complete activation of the Refurbishment Subassembly Facility at KSC leading to assembly and checkout of the SRB for the first orbital flight.

During 1978, two more development motors were loaded and test fired. The development motor test series will be completed with the fourth and final development motor test planned for early 1979. The solid rocket motor qualification test series of three flight configured motors will also be fired in FY 1979.

Concurrent with the development motor testing in 1978, five ground test articles were manufactured and shipped to MSFC for tests. One SRB was used for structural testing and four (two empty and two inert loaded) for vibration testing. The manufacture of the first set of flight motors started during 1978. Shipment of the flight set of two SRMs to KSC for STS-1 will be completed by mid-1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The solid rocket booster estimate for FY 1979 has increased by $36.7 million. This increase was caused primarily by subsystem design changes particularly in the structures, integrated electronics, and recovery subsystems. Additional funds were also required for solid rocket motor design changes resulting from analysis of the development motor firings data.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, manufacture and assembly of the SRB structural systems will be completed for the DDT&E flight hardware. In addition, the assembly of the main and drogue parachutes will be completed for the final orbital development flight. The solid rocket motors for the last development flights will be manufactured at Thiokol and delivery of four sets to the launch site will be accomplished. The booster assembly contractor will assemble and checkout the SRBs for flight missions and will be involved with refurbishing and checkout of recovered hardware for use in subsequent flights.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- o Deliver four sets of flight hardware to KSC for the orbital flight test program
- o Complete assembly and checkout of flight SRBs at KSC for the OFT program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Launch and Landing..	104,012	128,100	146,200	99,200

OBJECTIVES AND STATUS:

The Space Shuttle launch and landing project includes the preparation of a series of Space Shuttle landing, ground processing and launch station sets at KSC and the Dryden Flight Research Center (DFRC) in California, and their operation through the approach and landing test and orbital flight test phases. These station sets include handling, testing, and servicing systems and ground support equipment. At KSC, the Launch Control Center contains the heart of the computerized automated launch processing system (LPS), which connects to many of the above stations for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing.

Approximately 1,430 design models of ground support equipment (GSE) for station sets have been defined, including some 810 provided by the vehicle development contractors and 620 provided by separate KSC GSE procurements. All of the GSE is on contract. About 55% of the development contractor GSE and 90% of the KSC GSE have been received. A major portion of the effort remaining in FY 1979 involves receiving the remaining GSE, installing and checking it out, and activating the resulting station sets.

All hardware and system software for the central data subsystem have been accepted. All major launch processing system operating software releases have been made to support the ground checkout software programs required for launch operations.

During 1979, the final phase of construction of facilities required for the first orbital flight will be completed. The launch processing system will be ready for mating with ground support equipment. All station sets in the first flow processing line will be activated and will complete operational readiness checkout before the first set of flight hardware reaches each respective station. Launch operations procedures will be prepared and verified for this same readiness schedule. Orbiter 102, the first flight sets of main engines and solid rocket boosters, and the first flight ET will be delivered to KSC starting in early 1979.

The development contractors' support activities and manpower buildup at KSC will continue and reach a peak during late 1979. The development contractors constitute the bulk of the launch team and are also the operators of the launch processing station sets, launch support equipment and the GSE. Processing of the vehicle for the first orbital flight will commence early in 1979. Flight elements will be assembled, checked out, serviced and launched for the first manned orbital flight. In addition, launch processing of some elements of the follow-on orbital flight tests will be in progress during 1979.

The development contractors' onsite launch support efforts at KSC have been initiated with Rockwell International (including both orbiter and main engine contractors), Martin Marietta, United Space Boosters, Inc., and Thiokol. These contractors are preparing specifications, procedures and test documentation for vehicle assembly, test, servicing, checkout and launch.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The $18.1 million increase in the FY 1979 estimate is due to the deferral of effort from FY 1978 and increased requirements in FY 1979. Due to the delay in shipment of the first flight elements to KSC, efforts such as ground support equipment (GSE) procurement, installation and checkout; propellant purchases; and launch processing system equipment buys were deferred into FY 1979. In addition, more replenishment spares were required, and the effort required to activate the various station sets (such as the orbiter processing facility, hypergolic system maintenance facility, and SRB disassembly area) was greater than previously planned.

BASIS OF FY 1980 ESTIMATE:

During 1980, the principal activities at KSC will focus on processing flight elements for the follow-on DDT&E orbital flight tests. After STS-1, the orbiter, which will land at DFRC, will be ferried back to KSC for reprocessing. In addition, the SRB's and parachutes used in this first flight will be recovered and disassembled for refurbishment and reuse.

Prelaunch processing of all elements required for the 2nd, 3rd and 4th orbital flights will be completed. Throughout this period, ground processing activities will be analyzed to reduce the vehicle turnaround time.

Site activation for all DDT&E Shuttle facilities are expected to be completed at KSC by FY 1980. Development contractors' support activities at KSC will also continue during this period. They will perform most of the launch operations for orbital flights STS-2, STS-3 and STS-4 and will operate the vehicle processing equipment throughout the launch site. In addition. planning will continue to achieve the increased launch rate capability required during the operational years.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- o Process flight elements for the orbital flight tests after STS-1
- o Conduct the first four orbital flight tests
- o Retrieval, recovery and processing of the reusable flight hardware from the orbital flight tests
- o Assess ground processing activities to improve the vehicle ground turnaround time

PRODUCTION

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Orbiter....	29,140	397,000	344,100	590,600	1-18
Main engine	12,560	18,000	81,300	80,300	1-19
Launch and landing	---	11,000	12,400	24,600	1-19
Spares and equipment	---	28,000	20,200	60,000	1-19
Total...	41,700	454,000	458,000	755,500	

OBJECTIVES AND STATUS:

Shuttle production provides for modification of the orbiter structural test article to orbital flight configuration (Orbiter 099), refurbishment of Orbiter 102 after the orbital flight tests and early operations period, and the fabrication and assembly of two additional orbiters to establish a national fleet of operational orbiters. Production activities also include fabrication of main engines, preparation of the second series ("second line") of Shuttle ground processing and launch support equipment at KSC to permit simultaneous processing of two Shuttle vehicles and the necessary Shuttle spares and equipment required to establish the initial inventory to support the operational flight rate capability of the Space Shuttle.

During FY 1979, the structural test program being performed at Palmdale, California, utilizing the orbiter structural test article (STA) airframe, will be completed. The test data will be used to certify the structural capability of the orbiter. After completion of the planned structural testing, which completes the development program requirements for the STA, it will be returned to the Rockwell plant at Palmdale to be converted to an orbital configuration (Orbiter 099). These modifications will consist of the removal of specific elements and instrumentation required during testing; installation of a flight-type crew module; addition of functional subsystems such as the orbital maneuvering system, the reaction control system, the atmospheric revitalization system, and the flight control and communications systems; and the application of the thermal protection system.

Fabrication and assembly of the major subsystems of Orbiter 103, which is scheduled for delivery to Vandenberg AFB early in FY 1983, has begun at Rockwell International and at the major structural subcontractors. The crew module and the forward and aft-fuselage elements are in assembly at Rockwell, and the wings, the vertical stabilizer, and the mid-fuselage are in assembly at Rockwell's subcontractors. Fabrication of the thermal protection system tiles has also begun. Some long lead ordering of critical parts will also be accomplished for Orbiter 104 during FY 1979. Efforts will be initiated during FY 1979 to identify and define a weight reduction program for implementation on Orbiters 099, 103 and 104. During FY 1979, NASA plans to negotiate a contract with the Canadians for remote manipulator flight systems, auxiliary equipment, and product support for the production orbiters. Funds appropriated for FY 1979 to maintain the option for possible fabrication of a fifth orbiter will also be used to begin procurement of critical long lead items. NASA will only order items which are common to a four or five orbiter program and not specifically for a fifth orbiter.

FY 1979 funding provides for continuation of long lead material and component procurements for those additional flight engines required for the operational orbiter fleet. Engine component procurements include hot gas manifold and preburner body forgings, turbopump castings, main combustion chamber parts and selected raw materials and plate stock for engine component fabrication. In addition, fabrication of liquid hydrogen and liquid oxygen high and low pressure turbopump components has been initiated and assembly of the first set of production engines will be started during FY 1979. Eventually, each subsystem of each engine will be individually tested up to its operating limits before being certified as flight ready and assembled into the complete engine.

Following completion of the Main Propulsion Test (MPT) program, the MPT engines will be returned to Rocketdyne to be refurbished for use with the production orbiters.

In order to provide the "second line" capability required at KSC during the operational years, the procurement of necessary additional ground and launch support equipment has been initiated during FY 1979. This equipment will be installed in the Orbiter Processing Facility and the Launch Control Center. NASA has also initiated the procurement of flight crew equipment for the extravehicular mobility unit (space suit), communications equipment, and the portable oxygen system. In addition, procurements for ET and solid rocket booster rate tooling will be initiated later in FY 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current FY 1979 estimate has been increased by $4.0 million reflecting the action of the Congress in appropriating funds to maintain the option for a fifth orbiter vehicle. In addition, the production funding has been rebalanced to accelerate procurement of the follow-on production main engines as recommended by the Covert Committee and to provide funds in production for engines assigned to Orbiter 099.

BASIS OF FY 1980 ESTIMATE:

Orbiter

Modification of Orbiter 099 to orbital flight configuration will continue during FY 1980 for delivery to KSC in 1981. Fabrication of a new crew module and other major subsystems, such as the orbital maneuvering system and the reaction control system, will be continued for assembly into Orbiter 099.

During FY 1980, fabrication of the major structural elements for Orbiter 103 will continue. These activities will include the aft fuselage, crew module, wings, and TPS tiles. In addition, manufacture will be initiated on subsystems such as the orbital maneuvering system, reaction control system, flight control and communications systems, and environmental control systems.

In FY 1980, fabrication will begin on the fourth flight vehicle, Orbiter 104, which is planned for delivery to KSC in FY 1984. The efforts will consist of continuing the procurement of long lead items such as basic materials and forgings by the major structural subsystem contractors. Selected subassembly vendors with a long lead time fabrication cycle will also continue manufacturing hardware for Orbiter *104.* The weight saving activities initiated in FY 1979 will be continued during FY 1980 to support Orbiter 099, 103 and 104 deliveries.

In FY 1980, remote manipulator system (RMS) production will also continue in order to provide the arms, spares and ground support equipment for follow-on operational use.

Main Eneine

Production engine materials and component procurement will continue during FY 1980. Component deliveries such as forgings, turbopumps, main combustion chamber parts, and other engine parts will be phased to support the fabrication and assembly operations. Fabrication and assembly of engines for installation into Orbiter 099 will be completed and delivered to KSC during FY 1980. Fabrication and assembly of engines for installation into Orbiter 103 will be well underway by the end of FY 1980. An early delivery of production engines was recommended by the Covert Committee to provide additional hardware in the event it is needed for development testing. All engines will also undergo acceptance testing at NSTL before delivery to KSC.

Launch and Landing

The capability at KSC to support simultaneous launch processing and checkout of two orbiter vehicles requires the procurement of additional ground and launch support equipment. In FY 1980, the procurement of this "second line" capability will be continued. The FY 1980 efforts will increase for ground support equipment purchases, installation in the Orbiter Processing Facility Bay No. 2 and the two remaining high bays of the Vehicle Assembly Building, modifications to the second mobile launch platform, and installation of launch processing system equipment in the Launch Control Center's second firing room.

Spares and Equipment

Shuttle spares and equipment include orbiter flight and ground support equipment spares, main engine spares, KSC launch site ground support equipment spares and crew equipment. Solid rocket booster and ET rate tooling required to increase the rate of production during the operational years is also provided.

During FY 1980, NASA will initiate procurement of flight spares for the required orbiter subsystems and main engine component spares, and will continue purchasing tooling for the solid rocket booster and ET increased production rate required for future operational years.

SPACE FLIGHT
OPERATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Space transportation systems operations capability development	65,400	110,500	109,300	128,600	2-3
Development, test and mission support	171,900	163,000	160,000	172,600	2-15
Advanced programs	10,000	5,000	7,000	13,000	2-21
Space transportation system operations	16,500	33,400	33,400	153,100	2-23
*Planning and program integration	4,000	---	---	---	
Total	267.800	311.900	309.700	467,300	

Distribution of Program Amount by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Johnson Space Center	124,904	152,900	144,520	170,800
Kennedy Space Center	54,065	53,650	56,133	71,700
Marshall Space Flight Center	77,379	93,500	86,207	208,450
National Space Technology Laboratories	6,100	5,900	6,092	5,500
Goddard Space Flight Center	2,116	1,950	3,465	6,700
Jet Propulsion Laboratory	475	50	---	---
Ames Research Center	125	50	---	---
Langley Research Center	50	50	---	---
Lewis Research Center	200	50	---	---
Headquarters	2,386	3,800	13,283	4,150
Total	267.800	311.900	309.700	467.300

*Beginning with FY 1979, this effort is funded within the Space Applications program.

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes Space Transportation Systems Operations Capability Development; the common support activities conducted under Development, Test and Mission Support; Advanced Programs; and Space Transportation System Operations.

Space Transportation Systems (STS) Operations Capability Development provides for space transportation system development other than the Space Shuttle and payload and operations support activities. These development and support activities are necessary to facilitate the planning and orderly transition to STS operations, which will provide the means for expanding capabilities in space while reducing the cost of operations. Principal areas of activity include the Spacelab, the STS Upper Stages, Multimission and Payload Support Equipment, Mission Control Center Upgrading (Level II), Payload and Operations Support (including Skylab Reboost/Deorbit) and Thrust Augmentation.

Development, Test and Mission Support provides the common engineering, scientific and technical support required at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories for Space Transportation Systems research and development activities.

The Advanced Programs effort provides technical as well as programmatic data for the definition and evaluation of potential future space missions and systems. In support of this effort, advanced development activities are conducted to obtain significant performance reliability improvements and reduce future program risks and development costs through the effective use of new technologies.

Space Transportation System Operations will provide the transportation services and operational activities to bring about a new era in capitalizing on the unique advantages of space to achieve expansion of human knowledge and practical benefits on Earth. The Space Transportation System Operations activities integrate the Space Shuttle system, the Spacelab, and the Upper Stages into a versatile and economical system; accomplish mission planning; provide the operational recurring hardware and consumables; and support all launch, flight recovery, crew and related activities.

Space Transportation System (STS) Operations Capability Development

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Spacelab	21,600	39,000	39,000	58,800	2-5
Space transportation system upper stages	8,400	16,500	16,500	18,300	2-7
Multimission and payload support equipment	5,378	10,000	10,600	9,600	2-9
Mission control center (MCC) upgrading (Level II)	5,400	13,000	13,000	16,000	2-11
Payload and operations support	24,622	32,000	30,200	10,900	2-11
(Skylab reboost/deorbit)	(18,500)	(20,500)	(20,500)	(---)	---
Thrust augmentation	---	---	---	15,000	2-13
Total	65,400	110,500	109,300	128,600	

OBJECTIVES AND STATUS:

The Space Transportation Systems Operations Capability Development activity includes six major areas of effort: Spacelab, Space Transportation System Upper Stages; Multimission and Payload Support Equipment; the Mission Control Center (MCC) Upgrading (Level II); Payload and Operations Support including Skylab Reboost/Deorbit, and Thrust Augmentation.

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of ESA's Spacelab development effort includes development of support equipment not provided by ESA. Other activities include procurement of flight hardware, and system activation activities which assure Spacelab compatibility with the orbiter and which will lead to an operational capability.

The STS Upper Stages, which consist of the Inertial Upper State (IUS) and the Spinning Solid Upper Stage (SSUS), are an integral part of the Space Transportation System. They are expendable, propulsive stages required to provide the capability to deploy Shuttle-launched payloads to high energy orbits not attainable by the Shuttle alone. The IUS, being developed by the Department of Defense, is a multi-stage, solid propellant expendable vehicle which will become operational in 1980 on a Titan launch. The first Space Shuttle/IUS launch is planned for early 1981 (Tracking and Data Relay Satellite System). The IUS will be used for delivery of up to 5,000 pound payloads to geosynchronous orbit and for high energy planetary missions. The Spinning Solid Upper Stages (SSUS), being developed by the McDonnell Douglas Corporation as a commercial venture, are spin-stabilized, solid propellant expendable upper stages sized to be used for Delta and for Atlas-Centaur class payloads to be launched into geosynchronous orbit. The SSUS will become operational in 1980.

Multimission and Payload Support Equipment consists of ground and flight hardware used for interfaces between the payloads and the space transportation system, as well as test equipment to verify payload integration compatibility. This class of hardware will be developed into a standard, reusable inventory for a variety of payloads.

The Mission Control Center Upgrading (Level II) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Level II will provide additional hardware, equipment, and software required for configuring the MCC to provide the capability to support two simultaneous orbiter missions, ground simulation network, and an MCC-launch site interface.

The Payload and Operations Support activity consists of four major areas of effort: Operations Management Support, Orbital Flight Test (OFT) Payload Integration, Payload Operations Control Center (POCC) and Skylab Reboost/Deorbit. The Operations Management support efforts are focused on determining the most efficient method of operating the space transportation system. The Orbital Flight Test Payload Integration provides for integrating payloads on the OFT flights during the 1979-1980 period. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads. The Skylab Reboost/Deorbit activities which were intended to provide a capability to adjust the orbit of Skylab with a Teleoperator Retrieval System (TRS) during the orbital flight test phase of the Shuttle program are being terminated. The prime contract for the TRS development was terminated in December 1978; however, selective subsystem contracts will be completed. This work should be completed by mid-1979. At that time, residual Skylab Reboost/Deorbit funds will be applied to Shuttle related activities.

Thrust Augmentation is the definition of requirements to provide the additional thrust necessary to insure full Space Shuttle system payload deployment capability of orbiter missions launched from the Vandenberg Air Force Base. Of the possible Thrust Augmentation options studied, the concept of adding a small strap-on solid rocket to each solid rocket booster was the approach selected. Adding strap-on solids to the external tank will be investigated as a capability growth option.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The STS Operations Capability Development estimate has decreased by $1.2 million. Specific changes are explained within each project.

BASIS OF FY 1980 ESTIMATES:

FY 1980 Spacelab funds are required for fabrication and test of the crew transfer tunnel and for ground support equipment. In addition. continuation of NASA program efforts are required for testing of Spacelab during the verification flights; continuation of work on unique hardware to support the Spacelab in the Shuttle orbiter cargo bay and studies to assure compatibility of Spacelab and Shuttle. Funding is also required for incremental procurement of flight hardware from the European Space Agency (ESA), and procurement of initial spares to support early Spacelab missions.

STS Upper Stages funds are required in FY 1980 for continued development of NASA-unique hardware and software to support IUS mission planning and implementation. Funds will also be used for integration planning and system verification of the Spinning Solid Upper Stages.

FY 1980 funding for Multimission and Payload Support Equipment is required to complete development of the trace gas analyzer and the payload specialist station (PSS); initial design of the mixed cargo support hardware; activation of the first set of cargo integration and test equipment (CITE); initial design and development of the CITE dual capabilities and mission kit equipment; and checkout of the self-contained payload containers.

FY 1980 funding is required to support continued progress in upgrading the Mission Control Center at the Johnson Space Center, including completion of the design specifications for multi-vehicle command and control software and related systems and the initiation of systems integration and testing.

in addition, FY 1980 funds are required to activate the Payload Operations Control Center in support of orbital flight test payloads, as well as integration of hardware and software activities for these missions. Operations Management Support will continue to focus on alternative modes of operating the Space Transportation System (STS), as well as payload retrieval operations techniques, the analyses of STS user reimbursement policies, ground and flight operations analyses, and selected hazard analysis studies. The baseline flight planning activities for orbital flight tests will be completed in FY 1980, including the necessary safety reviews, integrated cargo loads and thermal analyses, and ground and launch operations activities.

No funding is required in FY 1980 for Skylab Reboost/Deorbit.

Thrust augmentation funding in FY 1980 is required for systems engineering, testing and engineering analyses to determine performance of the thrust augmentation concept as well as the thermal and loads impact on the total Shuttle system and facilities.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacelab	21,600	39,000	39,000	58,800

OBJECTIVES AND STATUS:

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA) to provide a versatile, reusable space laboratory which will be flown to and from Earth orbit in the cargo bay of the Shuttle. The Spacelab will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. It will permit researchers to personally conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, of which nine are members of the European Space Agency, are participating in the program. NASA and ESA are committed to bear the cost of their respective program responsibilities. ESA responsibilities include the design, development, production and delivery of the first Spacelab and associated ground support equipment to NASA, and the capability to produce additional Spacelabs. NASA funding responsibilities include development of flight and ground support equipment not provided by ESA, development of Spacelab operational capability and procurement of additional hardware needed to support NASA's missions.

In FY 1979, fabrication of the crew transfer tunnel will be continued. This tunnel will link the Spacelab module to the Shuttle orbiter cabin. Manufacture, test and validation of verification flight instrumentation equipment which includes sensors, electronic measuring and monitoring devices, and related flight and ground support equipment required to verify the performance of Spacelab subsystems and to monitor the environment to which payloads will be subjected, will also be continued.

Much of the U.S. developed ground support equipment will be completed in the latter part of FY 1979. The Software Development Facility will become operational in late FY 1979. The equipment in this facility, including a Spacelab command and data management subsystem computer with interfacing equipment and spares, will be used for maintenance of the software that ESA is developing, as well as for developing the application software for each Spacelab mission. Manufacture of the Spacelab training simulator, will also be continued. The simulator will be used at the Johnson Space Center to train flight controllers and flight crews in systems activation, control, and monitoring; it will also be used to support the development and verification of flight procedures. The adaptation of engineering pallet structures with systems being developed for use on some of the Shuttle orbital flight test missions will be completed in FY 1979.

In FY 1979, the Spacelab integration contractor will perform systems engineering, logistics planning, systems software preparation, and analytical experiment integration to prepare for the orbital flight tests in late 1979-1980, and the two Spacelab verification flights scheduled for 1981 and 1982.

In addition, the procurement of follow-on Spacelab hardware will be initiated in FY 1979 with the European Space Agency.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

There is no change in the FY 1979 estimate, although Congressional action on the FY 1979 budget request reduced the funding by $1.2 million on the assumption that the proposed barter arrangement would be successful. The $1.2 million has been restored to Spacelab to accommodate increased requirements because of failure to consummate a barter agreement. This funding was provided from elements of Payload and Operations Support.

BASIS FOR FY 1980 ESTIMATE:

The FY 1980 funding is required for incremental procurement of flight hardware from ESA, and the procurement of initial spares to support early year flight activities. During FY 1980, effort will be continued on development of the ground support equipment to be provided by NASA. Ground support equipment requirements include unit testers required for preinstallation checkout and subsequent fault isolation of electronic equipment; transportation equipment required to load and unload Spacelab elements from transporter aircraft; positioning equipment to handle heavy components within the modules during ground operations; and outfitting the workstands in the operations and checkout building, and equipment to support the integration and checkout of the Spacelab during ground operations.

In FY 1980, the subsystem development and verification of the orbiter and Spacelab avionics interface will be continued at the Johnson Space Center. Development of the experiment computer operating system will be completed. During 1980, the upgraded engineering model pallets will be flown on two of the orbital flight test missions.

In addition, FY 1980 funding is required to continue integration contractor efforts at the Marshall Space Flight Center and the Kennedy Space Center. Examples include support of systems engineering, systems software, logistics and analytical integration activities, design engineering support, preparations for systems preflight and postflight processing, payload integration, and preparations for postflight Spacelab disassembly and refurbishment for subsequent reuse.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Space Transportation System (STS) Upper Stages................	8,400	16,500	16,500	18,300

OBJECTIVES AND STATUS:

The Space Transportation System (STS) Upper Stages are required to provide the capability to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These Upper Stages are the Inertial Upper

Stage (IUS) and the Spinning Solid Upper Stage (SSUS) required for delivery of payloads to geosynchronous orbits and for high energy missions, such as planetary exploration missions.

The Inertial Upper Stage is being developed by the Department of Defense (DOD). It is a multi-stage, solid propellant expendable vehicle and will be operational in 1980. NASA is coordinating the incorporation of the NASA-unique and other non-DOD requirements with the DOD during the design, development, test and evaluation phase to insure IUS operations compatibility with the Space Transportation System. The IUS will be used for delivery of up to 5,000 pound payloads to geosynchronous orbit and for high energy lunar and planetary missions.

The Inertial Upper Stage (IUS) payload capability exceeds the capability needed by many geosynchronous payloads using today's expendable launch vehicles. The Spinning Solid Upper Stage (SSUS) is being developed commercially for these smaller payloads in two weight classes. The Delta-Class (SSUS-D) will be capable of injecting 1,250 pound payloads into geosynchronous transfer orbit, while the Atlas Centaur Class (SSUS-A) will be capable of injecting 2,250 pound payloads into the same orbit. The SSUS-A and SSUS-D offer the user community launch cost economies. These relatively low cost upper stages have simple physical and functional interfaces for payloads and facilitate an early and orderly transition from the current expendable launch vehicles to the operational STS. Two SSUS-A's or four SSUS-D's with their spacecraft can be flown on a single Shuttle flight. As a result. the launch costs to the user are significantly reduced,

During FY 1979, DOD will continue the IUS full scale development phase. NASA's IUS funding will support the NASA-unique hardware and software items, including mission related hardware and software, ground support equipment, operations support and IUS/STS integration and simulation/training.

The Spinning Solid Upper Stages (SSUS) are being developed by the McDonnell Douglas Corporation as a commercial venture. Funding for the SSUS program in FY 1979 supports the SSUS operations capability development effort necessary to accommodate the commercially developed SSUS-A and SSUS-D systems. This effort includes planning, analyses, preparation for ground processing and flight operations and procurement of hardware and services for the initial SSUS flight in 1980.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 STS upper stages funding is required to continue to support the development of the NASA-unique IUS configurations. This effort includes modifications to the basic DOD IUS hardware and airborne support equipment. In addition, the funding will support the development of NASA IUS launch site ground operations capability; IUS/orbiter integration analyses and testing; and the development of IUS mission planning and flight operations capability. The first NASA IUS mission is planned for 1981.

FY 1980 funding is also required for system verification of the SSUS, procurement of hardware and services, and support of Shuttle integration analysis, mission and flight operations planning and ground operations planning. The first SSUS flight is planned for 1980 on an orbital flight test mission.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Multimission and Payload Support Equipment....................	5,378	10,000	10,600	9,600

OBJECTIVES AND STATUS:

Multimission and Payload Support Equipment consists of equipment required to integrate and check out payload elements, and a class of ground and flight hardware that will provide an interface between the payloads and elements of the Space Transportation System (STS). These requirements can be furnished more economically from a standardized equipment inventory than by individual payload users. This reusable equipment is being developed to integrate, check out, transport, and operate a wide range of applications, science, and technology payloads. The equipment will support activities such as payload checkout, STS/payload integration and ground operations at the launch and recovery site, and orbital payload operations.

Examples of this type of standardized equipment are:

(1) Payload Transportation Equipment - The Super Guppy will be procured in FY 1979 for cross-country transportation of payloads (regular and outsized) to and from the Kennedy Space Center and the Western Test Range. Intrasite payload equipment is also being developed for use at the launch site to move integrated cargoes to and from the Shuttle orbiter.

(2) Payload Specialist Station Equipment - This equipment is required to conduct payload operations from the orbiter's aft flight deck. A concept utilizing existing technology has been defined and will satisfy the majority of payload functional command and display requirements, as well as mixed cargo integration and operations on early space transportation system missions. This approach will minimize the need for payload-unique equipment and operational changeout time.

(3) Mixed Cargo Support Equipment - This equipment will provide maximum flexibility for mixing cargoes in the orbiter bay, as well as decreasing installation and checkout time. The use of identical equipment for different payload configurations will allow simple crew interface and training. Examples of this equipment include standard cable harnesses which will allow command and data feedback simultaneously from up to four payloads in the orbiter cargo bay; and timing buffers which will provide various time signals to the Shuttle attached payloads while they are active.

(4) Flexible Multiplexer/Demultiplexer - The flexible multiplexer will combine the orbiter data stream and up to five separate payload telemetry or command data streams into a single output signal. The function

of the flexible demultiplexer is to separate the combined data signal, either telemetry or command, back into the appropriate orbiter or payload data streams.

(5) Cargo Integration and Test Equipment (CITE) - This equipment is required to integrate and checkout payload elements as they are assembled into a complete cargo to be flown on the Space Transportation System. CITE will verify the compatibility of the cargo to Shuttle interfaces, and assure that cargo elements do not interfere with each other.

(6) Trace Gas Analyzer - The trace gas analyzer system will perform in-flight monitoring of the aggregate "offgassing" constituents from payloads and metabolic sources in the Spacelab pressurized module. Its primary subsystems consist of a gas chromatographic column to detect the presence of an atmospheric substance and a mass spectrometer to measure the concentration of each of the atmospheric constituents.

(7) Mission Kits - The mission kits consist of standard and optional flight hardware designed to extend the capabilities of the payload and/or the orbiter to support the mission as dictated by the payload requirements. Examples of these items are self-contained payload containers and nitrogen tanks.

FY 1979 funding is being used for the continued design and development of the payload specialist station; the self-contained payload containers; intrasite payload transportation equipment; the trace gas analyzer and to complete the development of the flexible multiplexer/demultiplexer. Manufacturing and testing of the structural/mechanical cargo integration and test equipment will be completed in FY 1979, and the procurement of the Super Guppy for transporting payloads will also be accomplished.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The $600 thousand dollar increase from the budget estimate is a net increase resulting from the addition of the Super Guppy for air transportation, offset by rephasing and minor baseline changes for various items including deferring portions of the trace gas analyzer development efforts and rephasing and decreasing payload specialist station equipment requirements.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding is required to continue manufacture and testing of the trace gas analyzer and the payload specialist station. FY 1980 funds will support the design and development of the mixed cargo support equipment and mission kits. The first set of cargo integration and test equipment (CITE) will be activated in FY 1980 and the procurement of spares will be completed. The FY 1980 funding will also support the checkout of the self-contained payload containers.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Mission Control Center (MCC) Upgrading (Level II)	5,400	13,000	13,000	16,000

OBJECTIVES AND STATUS:

Mission Control Center (MCC) Upgrading (Level 11) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. MCC Level I, funded under the Shuttle development program, provides hardware, equipment and software to configure the MCC to support Shuttle development flights. MCC level II will provide hardware, equipment, and software to upgrade the MCC with the capability to support two simultaneous orbiter missions, a ground simulation network, and a MCC-launch site interface.

In FY 1979, the definition of the overall system requirements will be completed. Design specifications for multi-vehicle command and control software, data distribution, display control, and flight planning systems will be finalized. Implementation of these systems will commence in support of early flight control configuration requirements. Procurement and installation of hardware for vehicle command and control, and display control will be initiated.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding is required to complete the design specifications for multi-vehicle command and control software and related systems and to initiate systems integration and testing. Software development, including the design, checkout and testing of the trajectory, telemetry and command software systems, will be continued. Communications interface equipment such as air-ground voice, telemetry processing, wide band switching and data handling equipment will be procured and installed. In addition, display, control, and data distribution equipment, such as console TV monitors and modules, computer interface multiplexers and initial equipment for the text and graphic system, will be provided in FY 1980.

Payload and Operations Support	24,622	32,000	30,200	10,900
(Skylab Reboost/Deorbit)	(18,500)	(20,500)	(20,500)	(---)

OBJECTIVES AND STATUS:

The Payload and Operations Support activity consists of four major areas of effort: Payload Operations Control Center (POCC); Operations Management Support; Orbital Flight Test (OFT) Payload Integration; and Skylab Reboost/Deorbit.

The Payload Operations Control Center, to be located at the Johnson Space Center, will provide for command and control of payloads that operate in the Shuttle and Spacelab. It will operate in conjunction with the JSC Mission Control Center. Funding is required for the design and development of computers, displays, communication links, and associated software. In FY 1979, system level requirements definition and design will be completed. The POCC will become operational in conjunction with the Mission Control Center Upgrading (Level II).

Operations Management Support will focus on defining the most efficient mode of operating the Space Transportation System (STS). In FY 1979 the definition of STS user requirements, flight kit planning, analysis of STS cost per flight, analysis of payload data retrieval, and range safety studies will be continued.

The Orbital Flight Test (OFT) Payload Integration provides for the integration of payloads on the OFT flights during the 1979-1980 time period. The activities involved include management integration such as planning, scheduling, and coordinating all elements; interface definition in environmental, structural, and thermal areas; safety analysis; hardware integration; flight support; and development of the interface control document. The FY 1979 funds support conceptual flight planning, launch site planning, and thermal and loads analysis for payloads to be flown on the Shuttle orbital flight test missions.

The primary objective of the Skylab Reboost/Deorbit was to provide NASA with the capability to adjust the orbit of Skylab. This capability was to be provided by a Teleoperator Retrieval System that would allow either of two maneuvers: boost the Skylab into a higher orbit to extend its orbital lifetime, or provide the impulse to guide Skylab reentry into a predetermined remote ocean area. In December 1978, after a reassessment of the Skylab Reboost/Deorbit program, NASA discontinued plans for reboosting or deorbiting Skylab because of a limited chance of success. Three major factors which led to this decision were: (1) general deterioration of systems aboard the Skylab and consequently the unlikelihood of continuous operation through the February/April 1980 time period; (2) tight turnaround time between the first and second orbital flight test missions if the first manned orbital flight test is delayed; and (3) the probable delay in the TRS delivery schedule. The FY 1979 funding will support the termination of the TRS prime contractor effort, but will allow selective subsystem contracts to be completed. This work should be completed by mid-1979. At that time, any residual Skylab Reboost/Deorbit funds will be applied to Shuttle-related activities. Pending final closeout requirements, the FY 1979 budget estimate has not been revised.

CHANGES FROM FY 1979 BUDGET ESTIMATES:

The Payload and Operations Support budget in FY 1979 has been reduced by $1.8 million. Of this amount, $600 thousand has been allocated to Multimission and Payload Support Equipment to support the Super Guppy procurement. In addition, $1.2 million has been restored to Spacelab to accommodate increased requirements because of failure to consummate a barter agreement.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding for the Payload Operations Control Center (POCC) will support continued development of hardware and software systems to allow payload command and control and some data review and analysis. The POCC will also provide limited support to the orbital flight test payloads in the late 1979-1980 time period.

FY 1980 funding for Operations Management Support is required to continue definition of user requirements, analysis of STS cost per flight, definition of ground and flight operations techniques, and safety studies.

Orbital Flight Test Payload Integration funding in FY 1980 is required for the integration and handling of payloads for the OFT missions in the late 1979-1980 time period.

No funding is required in FY 1980 for Skylab Reboost/Deorbit.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Thrust Augmentation	---	---	---	15,000

OBJECTIVES AND **STATUS**:

Additional thrust is necessary to ensure that the full Space Shuttle system payload deployment capability of 32,000 pounds and 25,000 pounds retrieval capability can be achieved for the 98^{o} inclination, 150 NM circular shuttle mission launched from Vandenberg Air Force Base. The current projected capability is not sufficient to perform this mission. Payloads requiring the full lift capability have been identified. Therefore, to prevent the need for maintaining large expendable launch vehicles, it is necessary to develop a thrust augmentation. During 1978, a number of possible thrust augmentation options were studied, and the selected approach is the addition of a small strap-on solid rocket motor to each solid rocket booster (SRB). The addition of strap-on solid rocket motors to the external tank will be investigated as a capability for a growth option; the external tank strap-ons would be ignited after SRB separation.

BASIS OF FY 1980 ESTIMATE:

In order to achieve the necessary operational capability in 1984, effort must begin in FY 1980 to study the impact of the thrust augmentation on each element (orbiter, external tank, and solid rocket booster), as well as the impact on the overall system and launch facility. A full implementation decision can be deferred until FY 1981; however, funds in the amount of $15 million in FY 1980 will be required for analyses and initial design activities.

This work will include systems engineering tests, wind tunnel and model tests, structural and aerodynamic loads analyses, and studies to identify the performance of the strap-on solid rocket motors. The FY 1980 effort will also consist of systems engineering activities to understand the aerothermal, structural, dynamic, and vibro-acoustic impact of the strap-on motors on the external tank and solid rocket boosters. Facility requirements will also be studied.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

DEVELOPMENT, TEST AND MISSION SUPPORT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Research and test support	44,846	40,000	40,000	41,900	2-16
Data systems and flight support	45,562	49,300	46,300	47,000	2-17
Operations support	43,954	38,800	39,900	39,500	2-18
Launch systems support	37,538	34,900	33,800	44,200	2-19
Total	171,900	163,000	160,000	172,600	

OBJECTIVES AND STATUS:

Development, Test and Mission Support provides the common engineering, scientific and technical support required to conduct ongoing and proposed space transportation systems research and development at the Johnson Space Center, the Kennedy Space Center, the Marshall Space 'Flight Center and the National Space Technology Laboratories. Development, Test and Mission Support (DTMS) functions include research and test support, data systems and flight support, operations support, and launch systems support. These common efforts are necessary to support early project definition; to provide engineering support for indepth technical examination of development efforts of prime and major subcontractors on space transportation systems projects; to provide common support equipment and supplies; and to perform backup design, testing and analysis in high technology areas of design and development.

CHANGES PROM FY 1979 BUDGET ESTIMATE:

The decrease of $3 million in the N 1979 budget estimate for Development, Test and Mission Support is the result of Congressional authorization action.

BASIS OF FY 1980 ESTIMATE:

FY 1980 DTMS funding provides for the common engineering, scientific and technical support required for all Space Transportation Systems programs. This support is required for activities performed under Space Shuttle, Space Transportation Systems Operations Capability Development, and Advanced Programs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Research and Test Support....................................	44,846	40,000	40,000	41,900

OBJECTIVES AND STATUS:

Research and Test Support encompasses a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. These activities complement the work of the major development contractors located across the country in contractor-owned plants and government facilities.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, research and test support efforts will be focused primarily on critical Space Shuttle activities including the orbital flight test activity. Also supported will be design and development activities under STS Operations Capability Development, and research and development efforts in Advanced Programs. Engineering and test support is provided to assure achievement of technical goals as they related to each program.

Examples of FY 1980 Space Shuttle support to be provided at the Johnson Space Center include: (1) support of the Shuttle avionics integration laboratory for ascent, on-orbit and abort mission phases of the Shuttle avionics system; (2) continuing support of the communications and tracking systems space-to-ground compatibility and performance testing; and (3) analysis and certification of government-furnished equipment, environmental control life support systems, structural and propulsion subsystems and crew station training through utilization of mockups, neutral buoyancy crew station trainers and the remote manipulator facility.

At the Marshall Space Flight Center, FY 1980 funding provides for: (1) support of the Shuttle main engine static test firing activities and integrated component testing, as well as the qualification of the main propulsion system; (2) refurbishment efforts for the solid rocket booster hardware; (3) engineering support for the Shuttle orbital flight test activity; and (4) flight evaluation of the Shuttle external tank, solid rocket booster, Space Shuttle main engine and related systems.

FY 1980 research and test support funds are also required at the Johnson Space Center and the Marshall Space Flight Center to support Space Shuttle certification inspections, tests, configuration control panels, and integration efforts.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of bollars)		
Data Systems and Flight Support	45,562	49,300	46,300	47,000

OBJECTIVES AND STATUS:

Data Systems and Flight Support efforts are associated with the ground-based flight data systems, flight simulation systems, special purpose and general purpose data systems, and flight support.

The ground-based flight data systems effort supports the definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control Center, including the real time computer complex and the Shuttle Data Processing Complex in support of the Shuttle orbital flight tests, as well as operation and maintenance of those facilities in preparation for operational mission support.

Flight simulation efforts include modification, operation and maintenance of the full-mission (both fixed-base and motion-base) and the part-task simulators which are used for flight crew training and for flight procedures development and validation for the development flight programs. Also included is the operation of the JSC central data computation facility and special purpose data system required to support Center-wide activities in mission analysis, systems engineering development, and test functions for the Shuttle program.

Flight support provides for development of Shuttle flight control and recovery plans and procedures, flight plans, flight data compilation, crew procedures and training, and other elements of the data base required for crew activities, operation and maintenance of the T-38 training aircraft, flight data management, and support of Shuttle payload accommodation and integration.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 data systems and flight support funding was decreased by $3.0 million because of the Congressional authorization reduction.

BASIS OF N 1980 ESTIMATE:

FY 1980 funding of ground-based flight data systems supports the upgrading of the Mission Control Center and provides flight support and flight data management functions for the orbital flight test effort. This effort will also include the operation of the software development laboratory, comprised primarily of the real time computer complex system required to develop and validate the Shuttle orbiter flight software.

FY 1980 efforts in flight simulation and development data systems will intensify in support of operations of both the fixed-base and motion-base simulators required for the high fidelity crew training. Data processing in the central computing facility will continue in support of mission and systems design and performance studies for the Shuttle. Flight support and flight data management functions in the orbiter data reduction complex and the Shuttle program information management system will continue in support of the orbital flight test effort.

Aircraft operations activities which will be supported in FY 1980 include maintenance, modification, and engineering support services relating to the T-38 training aircraft. FY 1980 funding requirements also provide for the flight control, crew training and engineering support of flight operations planning control for the orbital flight test missions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Operations Support	43,954	38,800	39,900	39,500

OBJECTIVES AND STATUS:

Operations Support provides for contractor effort and related supplies and equipment to operate and maintain onsite activities at the Johnson Space Center, the Marshall Space Flight Center, the Kennedy Space Center, and the National Space Technology Laboratories, and for offsite operations at the White Sands Test Facility.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Operations Support funding for FY 1979 was increased by $1.1 million to meet additional requirements for facility operations at the Kennedy Space Center in preparation for the Shuttle orbital flight test activity.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analyses, telecommunications, component fabrication, photographic support and logistics support.

Examples of specific services to be provided in FY 1980 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal furbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (3) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (4) engineering, installation, operation and maintenance of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photographic services including still and motion picture processing and audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of Center operations including receipt, storage and issue of research and development supplies and equipment, and transportation services; and (9) management services in support of Center operations, including data management, microfilming and preparation of technical documentation.

FY 1980 funds will also provide a basic level of maintenance, operation, and support services required at the White Sands Test Facility to support program requirements including material and component testing, and Shuttle orbital maneuvering systems test support.

In addition, FY 1980 funds will provide the basic level of support to the National Space Technology Laboratories for the static test firing and integrated component testing of the Space Shuttle main engine and the qualification of the main propulsion system.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Launch Systems Support	37,538	34,900	33,800	44,200

OBJECTIVES AND STATUS:

Launch Systems Support provides for the development and test of the checkout and launch facilities and associated ground support equipment, as well as the technical services required to support the test, checkout and launch of the Space Shuttle and payloads for the development test flights at the Kennedy Space Center.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

FY 1979 Launch Systems Support funding was decreased by $1.1 million to meet additional requirements for KSC facility operations support in preparation for the Shuttle orbital flight test effort.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 launch systems support requirements at the Kennedy Space Center are for the continuing preparation of the launch facilities to accommodate the Shuttle orbital flight test missions.

FY 1980 activities will support the integration and checkout of the space vehicle and its payloads and ground support systems to accommodate the Space Shuttle flight hardware and payload systems.

FY 1980 funding requirements provide for mechanical ground system activities involving operation and maintenance of launch systems and facilities for the Shuttle; support for development testing of the Kennedy Space Center-designed Shuttle equipment in the launch equipment test facility; maintenance and operation of the Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which supports maintenance activities.

FY 1980 funding will also support the electrical/electronic and launch instrumentation systems, such as automated checkout equipment, operational voice and TV communications, computations, measurements, and telemetry. These activities include operations and maintenance support of communication, computational and instrumentation systems for the Shuttle, and instrumentation and measurement support for development testing of the Kennedy Space Center-designed Shuttle equipment in the launch equipment test facility.

BASIS FOR FY 1980 FUNDING REQUIREMENTS:

ADVANCED PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Programs....................................	10,000	5,000	7,000	13,000

OBJECTIVES AND STATUS:

The Advanced Programs objective is to provide technical as well as programmatic data for the definition and evaluation of potential future space programs and systems. These efforts have continuously provided the basis for new programs and systems, such as the Apollo, Skylab, and the Space Shuttle. In support of these activities, subsystem studies and supporting development activities are conducted to demonstrate significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies.

In FY 1979, studies include use of the Space Shuttle for fabrication and erection of space structures and in-orbit construction techniques, and definition of a manned orbital transfer vehicle including crew module and propulsion module for geosynchronous mission operations. Definition of a 25-KW power system will be initiated in FY 1979.

CHANGES FROM FY 1979 ESTIMATE:

Congressional authorization and appropriation action on the FY 1979 budget request increased the funding by $2.0 million for the 25-KW power system efforts.

BASIS OF FY 1980 ESTIMATE:

In FY 1980 major emphasis will be placed on studies and definition of near-term mission options that are possible because of the operational capability and flexibility of the space transportation system. This includes orbital operations associated with the fabrication, deployment and operation of advanced space systems using space structures and space power systems, retrieval and reuse of space systems, long duration operations in low earth orbit, and systems to allow operational capabilities at geosynchronous orbit.

Advanced studies planned in FY 1980 include (a) continued definition of a manned orbital transfer vehicle including crew module and propulsion module for geosynchronous mission operations, (b) continued definition of space structures erection and construction in orbit techniques, and (c) definition of potential future power system requirements.

FY 1980 funding will also provide for the continued definition of a 25-KW power system and related evaluation efforts, The 25-KW power system would provide the capability for extended duration on-orbit operations and electrical power sources for payloads requiring additional power for longer periods of time than the Shuttle can accommodate alone. The 25-KW power system would be functionally, mechanically, and electrically compatible with the Shuttle orbiter interfaces. The power system would remain on-orbit in a stable, quiescent mode when not being utilized to support a space transportation mission or a free-flying spacecraft. It would be retrieved and returned to Earth in the cargo bay of the Shuttle for refurbishment or major repair.

In addition, FY 1980 funding is required for the definition of the solar electric propulsion stage (SEPS). The SEPS is a low-thrust, long-duration space propulsion system which would extend the Shuttle/IUS performance capability and permit a variety of additional high energy missions to be achieved. In addition to its role in automated high energy transportation, it could be used for mission support functions such as on-orbit servicing, orbit debris control and payload positioning and could provide a SEPS-based orbital test facility supporting technology demonstration of various space subsystems.

Subsystems studies and supporting development efforts will be conducted in support of these studies. The main objective is to evaluate technical feasibility in the critical areas involved.

SPACE TRANSPORTATION SYSTEM OPERATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Shuttle operations	14,800	21,200	21,200	114,600	2-23
Payload support operations	1,700	12,200	12,200	38,500	2-24
Total..	16,500	33,400	33,400	153,100	

OBJECTIVES AND STATUS:

Space Transportation System Operations will provide the transportation services and operational activites to bring about a new era in capitalizing on the unique advantages of space to expand human knowledge and increase the practical benefits here on Earth. Space Transportation System Operations will provide for the delivery of free flying payloads to low Earth orbit, conduct of experiments using the Shuttle orbiter as a carrier vehicle, conduct of experiments in the Spacelab, conduct of experiments using Spacelab pallets, delivery of payloads to synchronous and other high energy orbits using the combined capabilities of the Shuttle and upper stages, retrieval of free flying payloads from low Earth orbit, and on-orbit servicing of satellites. Operational flight missions will be planned and conducted to accomplish these activities in an efficient and economical manner by appropriate combination of payloads, experiments and mission objectives on specific flights. The Space Transportation System Operations activites integrate the Space Shuttle system, the Spacelab, and the upper stages into a versatile and economical system; accomplish mission planning; provide the recurring hardware and consumables; and support all launch, flight recovery, crew and related activities.

BASIS OF FY 1980 ESTIMATE:

Space Transportation System Operations funding in FY 1980 is required to support early NASA missions in 1981, 1982, and 1983. Activities include the continued procurement, assembly, and checkout of solid rocket booster, external tank, and upper stage flight hardware, as well as the development of flight operations plans and procedures for the Space Shuttle and payload support activities.

Shuttle Operations - Space Shuttle flight hardware components include the external tank and solid rocket boosters. External tank components will be delivered to the Michoud Assembly Facility in Louisiana and will be used to fabricate and assemble the liquid oxygen and liquid hydrogen propellant tanks. After final testing, the external tank will be shipped by barge to the Kennedy Space Center in Florida. The solid rocket booster electronic and instrumentation parts, thrust vector control components, recovery systems, attach structures, forward and aft skirts, separation motors, and solid rocket motors will be shipped to the Kennedy Space Center where final assembly and checkout will be performed prior to flight. FY 1980 funding is also required for the development of standardized orbiter avionics software programs, mission plans and trajectory analyses, crew training and procedures documentation, and payload-to-orbiter integration analyses. Detailed plans and procedures for missions to be flown in 1981 will be developed to reflect the unique mission profiles, structural load requirements and crew activities for each mission.

Payload Support Operations - FY 1980 payload support funding is required for the procurement of unique payload related hardware and services. Included are the upper stages which are required to provide the capability to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone; unique mission analyses such as spacecraft-to-upper stage analytical integration, special environment analyses required for unique payloads, and trajectory support for nonstandard orbits; maintenance and refurbishment of multi-use reusable mission related flight equipment; and flight operations planning for early Spacelab missions. FY 1980 funding includes the continued procurement and assembly of inertial and spinning solid upper stages, and analytical integration and special mission planning activities for payloads such as Galileo, International Solar Polar, Space Telescope, Solar Maximum Mission, Tracking and Data Relay Satellite System, and Active Magnetospheric Particle Tracer Experiment.

EXPENDABLE
LAUNCH
VEHICLES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS

EXPENDABLE LAUNCH VEHICLES PROGRAM

SUMMARY OF ES(REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of	Dollars)		
Scout..........	16,342	16,400	11,400	7,300	3-2
Centaur..........	41,458	21,500	21,500	18,300	3-4
Delta.	70,400	38,600	38,600	43,100	3-5
Atlas-F.	6,300	---	---	2,000	3-6
Total	134,500	76,500	71,500	70,700	

Distribution of Program Amount by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Kennedy Space Center.	11,235	7,800	9,660	3,800
Goddard Space Flight Center.	64,618	34,500	33,685	40,400
Langley Research Center.............................	16,100	16,300	11,340	7,200
Lewis Research Center....	38,203	16,700	15,822	16,400
Headquarters	4,344	1,200	993	2,900
Total.	134,500	76,500	71,500	70,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF SPACE TRANSPORTATION SYSTEMS

EXPENDABLE LAUNCH VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the expendable launch vehicles program is to provide for the centralized procurement of launch vehicles and launch support services for NASA's automated spacecraft missions. The program includes the procurement of launch vehicle hardware, launch services, engineering and maintenance, and, as required, development of improved vehicle systems, including the necessary ground support equipment. Launch vehicles currently being procured are: Scout, Centaur, Delta, and Atlas-F.

The expendable launch vehicles program includes funding for vehicle hardware, such as solid rocket motors, boosters, upper stages, shrouds, adapters, mission-unique hardware, and launch support including preparation of hardware for launch, guidance and control services, mission software, prelaunch and postlaunch engineering analysis, transportation, propellants, and range support. It also includes procurement of vehicle hardware to be used as back-up support for early users transitioning to the Space Transportation System.

Launches under this program are conducted from sites located at the Eastern Test Range in Florida, the Western Test Range in California, the Wallops Flight Center in Virginia, and the San Marco platform off the coast of Kenya, Africa.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Congressional appropriation action on the FY 1979 budget request reduced the funding by $5.0 million.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SCOUT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Scout	16,342	16,400	11,400	7,300

OBJECTIVES AND STATUS:

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a wide variety of small scientific satellites, space probes, and re-entry experiments. The first Scout launch occurred in July 1960. In the ensuing 18 years, there have been 98 launches, and 84 of these launches have been successful.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four-stage, solid propellant launch vehicle. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters (3.75 feet). It is capable of placing a 180 kilogram *(400* pound) payload in a 556 kilometer (300 nautical mile) orbit.

The Langley Research Center, located at Hampton, Virginia, has managed the Scout project since its inception. The prime contractor for the production, checkout, and launch of Scout is the Ling-Temco-Vought Aerospace Corporation, located in Dallas, Texas. Scout vehicles are launched from the Western Test Range, California; from Wallops Island, Virginia; and from the San Marco platform off the African coast near Kenya.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The *$5.0* million Congressional reduction in the Expendable Launch Vehicle budget was allocated to this project. The changes in FY 1979 consisted of rephasing the effort originally planned.

BASIS FOR FY 1980 ESTIMATES:

The funds required in FY 1980 will be used for engineering, technical support, vehicle testing and checkout, launch operations and maintenance of launch facilities and ground equipment. FY 1980 funds will provide for completion of launch service activity for the Magnetic Field Satellite to be launched from the Western Test Range. Preparation will be initiated for launching two San Marco cooperative missions in 1981 from the African San Marco launch platform.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

CENTAUR

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Centaur..	41,458	21,500	21,500	18,300

OBJECTIVES AND STATUS:

This project provides for the procurement and launch of the Atlas booster stage and the Centaur upper stage. The Centaur is a high performance upper stage, which is the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions, particularly planetary and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

In addition, the Centaur has been previously used with the Titan booster to launch heavier spacecraft beyond the capability of the Atlas Centaur. In this configuration, the Titan Centaur has successfully launched two Helios missions, two Viking missions, and two Voyager missions. Since NASA has no future plans to use the Titan Centaur vehicle combination, it has been phased out.

BASIS OF FY 1980 ESTIMATE:

Funds required in FY 1980 will provide for the post launch support of the HEAO-C mission planned to be launched in late FY 1979, for the procurement of Atlas Centaur vehicle hardware to provide backup support for users transitioning to the Space Transportation System, and for the phaseout of production capability at the prime contractor facilities. The last NASA mission using this vehicle system is HEAO-C. However, reimbursable launch support will be continued through CY 1981 in support of Intelsat and DOD missions. NASA's responsibilities for management and an orderly phaseout will be continued through this period.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

DELTA

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Delta	70,400	38,600	38,600	43,100

OBJECTIVES AND STATUS:

The Delta launch vehicle is the most widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 147 launches and has experienced a success record of over 91 percent. It is presently operational with two and three stage configurations and a multiburn second stage capability. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation.

The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. The third stage utilizes the Thiokol TE-364 solid motor, which is spin stablized. This vehicle, in its three-stage configuration, is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). It is capable of placing a 1,772 kilogram payload (3,900 pounds) into a 555 kilometer (300 nautical mile) orbit.

BASIS OF FY 1980 BUDGET ESTIMATE:

The FY 1980 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support NASA spacecraft requirements and to sustain a minimum production capability to back up early users scheduled on the Space Transportation System. Funds are also required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

ATLAS-F

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Atlas-F..	6,300	---	---	2,000

OBJECTIVES AND STATUS:

The Atlas-F is a one and one-half stage vehicle which uses liquid oxygen and kerosene as propellants. The vehicle is a refurbished surplus Intercontinental Ballistic Missile (ICBM) being managed by the USAF for space missions. NASA has used this vehicle to launch the TIROS-N and SEASAT missions, both of which were successfully launched during 1978.

BASIS FOR FY 1980 FUNDING REQUIREMENTS:

The $2 million required in FY 1980 will be used to modify the Atlas vehicle, including the fairing, and for the vehicle integration of the Search and Rescue missions. The Search and Rescue missions will be launched as piggy-hack missions with National Oceanic and Atmospheric Administration satellites beginning in 1982.

SPACE SCIENCE PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

Programs	Budget Plan			
		1979		1980
	1978 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Physics and astronomy...	224,200	285,500	282,900	337,500
Planetary exploration	147,200	187,100	182,400	220,200
Life sciences................	33,300	40,600	40,100	43,900
Total....	404,700	513.200	505.400	601.600

PHYSICS AND
ASTRONOMY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
High energy astronomy observatories development......	19,811	11.400	11.100	4.800	4-7
Solar maximum mission development....................	29.600	16.200	16.200	600	4-8
Space telescope development..........................	36.000	79.200	79.200	112.700	4-9
International solar polar mission development........	---	13.000	13.000	50.000	4-11
Shuttle/Spacelab payload development.................	27.061	38.300	34.900	41.300	4-13
Explorer development.................................	24.297	29.800	29.800	30.400	4-15
Mission operations and data analysis.................	19.298	23.300	25.000	36.500	4-17
Research and analysis................................	42.934	45.000	44.400	34.300	4-20
Suborbital programs..................................	25.199	29.300	29.300	26.900	4-25
Total..	224.200	285.500	282,900	337.500	

Distribution of Program Amount by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Johnson Space Center.................................	275	80	220	216
Marshall Space Flight Center.........................	85.394	115.114	125.138	158.112
Goddard Space Flight Center..........................	85.590	95.492	83.377	76.963
Jet Propulsion Laboratory............................	9.583	26.624	27.212	58.353
Wallops Flight Center................................	6.118	6.950	6.614	5.219
Ames Research Center.................................	15.477	13.013	7,238	4.157
Langley Research Center..............................	1.498	400	1.150	855
Lewis Research Center................................	738	---	200	---
Headquarters...	19.527	27,827	31,751	33.625
Total..	224.200	285.500	282.900	337.500

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF SPACE SCIENCE PHYSICS AND ASTRONOMY PROGRAM

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
High Energy Astronomy Observatories	HEAO-c	1979
Solar Maximum Mission	SMM	1979
Space Telescope	ST	1983
International Solar Polar Mission	ISPM	1983
Space Shuttle Orbital Flight Test Payloads	OFT	1980
Spacelab	Spacelab-1 -2	1981 1982

(Shuttle/Spacelab Payloads will build to a flight rate of two dedicated missions per year in 1984)

Explorers:

	Dynamics Explorer	1981
	San Marco-D/Multistationary San Marco-D/Low Orbit Solar Mesophere Explorer	1981 1981 1981
	Infrared Astronomical Satellite	1981
	Cosmic Ray Isotope Experiment	1981

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
	Active Magnetospheric Particle Tracer Explorer (AMPTE) Experiment	1982
	Cosmic Background Explorer	1984
	Extreme Ultraviolet Explorer	1984
Suborbital Programs:		
Sounding Rockets		About 60 launches per year
Balloon Flights		About 70 launches per year

OFFICE OF SPACE SCIENCE PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the Sun and the Earth's plasma environments; and of the origin, evolution, structure, and composition of the universe, including the Sun, other stars and celestial bodies. Under this program, research is being conducted to investigate the magnetosphere, the interplanetary medium, the Sun, the coupling that links these different plasma regions, and the processes that control them. Space-based investigations of cosmic ray, X-ray, gamma ray, ultraviolet, infrared, and radio emissions, not possible from ground-based observatories because of the obscuring effect of the Earth's atmosphere, give us a unique opportunity to study the Sun and other celestial bodies. The basic scientific research in the Physics and Astronomy program contributes to the knowledge necessary for the atmospheric research efforts in Space Applications. The investigations in Physics and Astronomy are the basis for increasing our knowledge of the fundamental laws of nature, especially those which control the environment of the Earth.

To achieve the objectives of the Physics and Astronomy program, NASA uses techniques ranging from theoretical and laboratory research through aircraft, balloon, and sounding rocket flights and then to small explorer spacecraft, automated observatories, and the Space Shuttle and Spacelab. Research teams involved in this program are located at NASA field centers, other government laboratories, universities, and industrial laboratories.

The scientific information obtained and the technology developed in the program are made available to the scientific and technical community for applications and the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been highly successful. Explorer satellites, a relatively low cost series of missions begun in 1958, have made a number of basic discoveries, including the discovery of the Earth's radiation belts, and have gone on to survey the Earth's near-space environment and to study its variation with space and time. They have also made major discoveries about celestial phenomena important to our understanding of the universe. The Explorers have contributed greatly to technology development and demonstration of precursor instruments that have flown later on observatories. The automated observatory missions to date include the first two missions of the High Energy Astronomy Observatory series, which were launched in August 1977 and November 1978. HEAO-1 has completed its mission and HEAO-2 is currently engaged in in significant high energy astrophysics investigations. Earlier observatories include the Orbiting Solar

Observatory series, the most recent of which (OSO-8) has just completed operations after three and one half years of acquiring data for solar and high energy astronomy investigations; and the Orbiting Astronomical Observatory series, the last of which (OAO-3) is in its seventh year of productive operations.

Major accomplishments during FY 1978 included the launch of the second observatory of the HEAO series, which will greatly expand our knowledge of the X-ray universe; the launches of the International Sun-Earth Explorers, which are improving our understanding of the dynamic interactions between the solar wind and the Earth's magnetosphere; the launch of the International Ultraviolet Explorer, which is obtaining high resolution data in the ultraviolet region of the spectra of stars and planets; and the commencement of development work on the most powerful astronomical instrument ever built--the Space Telescope, which will be launched on the Shuttle in 1983. The Space Telescope will be conducting research at the forefront of optical and ultraviolet astronomy during the final decades of this century. Major progress was also made in the development of the Solar Maximum Mission and several explorers, including the Dynamics Explorer and the Infrared Astronomical Satellite.

During FY 1979, work is continuing on the remaining mission of the High Energy Astronomy Observatory series (HEAO-C), which is scheduled for launch in 1979. This mission will study cosmic ray composition and initiate a limited survey of the gamma ray sky. Development efforts will be completed on the Solar Maximum Mission, which is planned for launch in 1979. Its primary objective is to conduct research on the physics of solar flares and solar transient events. Development efforts are continuing for the Space Telescope, experiments to be conducted on a Shuttle orbital flight test and Spacelabs 1 and 2, and instruments to be flown on follow-on Spacelab missions. Development work commenced in October 1978 for the International Solar Polar Mission to be launched in 1983. This mission will conduct exploration of the heliosphere, the space around the Sun, and obtain observations of the Sun over the full range of heliographic latitudes. Work is continuing on several explorers. The Dynamics Explorer to be launched in 1981 will investigate the interaction of the Earth's magnetosphere and ionosphere. The Infrared Astronomy Satellite, a cooperative mission with the Netherlands and the United Kingdom to be launched in 1981, will perform an infrared all-sky survey and study selected galactic and extragalactic sources. The San Marco-D mission is a cooperative program with Italy with two launches in 1981. A Cosmic Ray Isotope Experiment will be launched on a DOD satellite in 1981. Development work will commence in FY 1979 on the Solar Mesosphere Explorer, which will be launched in 1981. This mission will study solar ultraviolet flux and corresponding changes occurring in ozone and the related chemistry of the Earth's atmosphere as a result of variations in the incoming solar ultraviolet radiation during the solar maximum period. A number of explorer definition studies have been conducted, resulting in three future explorer missions: the Cosmic Background Explorer (COBE); Active Magnetospheric Particle Tracer Explorer (AMPTE); and the Extreme Ultraviolet Explorer (EUVE). COBE will carry out definitive measurements of the spectrum and directionality of the microwave background radiation believed to be a remnant of the "Big Bang" which began our present universe. AMPTE will study the solar wind at the subsolar point and identify particle entry windows, entry mechanisms, energization and transport processes into the magnetosphere. EWE will survey the entire celestial sphere at wavelengths between 100 and 1,000 angstroms, providing our first extensive information on super-hot "dying" stars. Scientific progress is also being achieved from the Mission Operations and Data Analysis program, the Research and Analysis program and the Suborbital program.

FY 1980 funding will provide for the continued development and launch of major flight projects, including launch operations and data analysis associated with the Solar Maximum Mission planned for a late 1979 launch; continuation of the work on the Space Telescope leading to a Shuttle launch in 1983; and continued work on the International Solar Polar Mission leading to a Shuttle launch in 1983.

With FY 1980 funding. work will also continue on experiment hardware, integration requirements and mission operations plans for the payloads to be flown on a Shuttle orbital flight test and on the Spacelab 1 and 2 missions, as well as development of payloads to be flown on follow-on Spacelab missions. These payloads include experiments in the astronomy, astrophysics, solar physics, and space plasma physics disciplines. The FY 1980 funding for the Explorer program will provide for continued work on Solar Mesosphere Explorer development, the San Marco-D missions, and hardware and subsystems and experiment fabrication for the Dynamics Explorer and Infrared Astronomical Satellite missions. Work is planned on one or more of the three upcoming explorers (COBE, AMPTE, EUVE) during FY 1980.

FY 1980 Missions Operations and Data Analysis activities will focus on the operations of and analysis of data from satellites which are producing valuable scientific data. These satellites include the first two High Energy Astronomy Observatories, the third Orbiting Astronomy Observatory, a Small Astronomy Satellite, the International Ultraviolet Explorer, the International Sun-Earth Explorers and an Atmosphere Explorer. Mission Operations and Data Analysis will also be underway for the remaining High Energy Astronomy Observatory and the Solar Maximum Mission.

For Suborbital programs, FY 1980 funds will provide for continuation of sounding rocket activity, including near concurrent launching of several rocket payloads for coordinated observation and for correlation with satellite observations and the continued operation of the Kuiper Airborne Observatory, and continuing scientific investigation through balloon flights.

FY 1980 Research and Analysis funding will support a broad range of efforts to provide the research and technology base required for well-conceived and defined future programs. In our supporting research and technology program, tasks critical to maintaining a firm scientific base for Physics and Astronomy will continue. In the area of Spacelab Science Payload Definition, efforts will continue on detailed studies of specific instruments. The Data Analysis activity will include operations of the National Space Science Data Center (NSSDC) and the general data analysis activities.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

HIGH ENERGY ASTRONOMY OBSERVATORIES (HEAO) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
HEAO spacecraft	9,865	9,065	8,765	2,300
HEAO experiments	8,904	1,735	1,735	1,400
Ground operations	1,042	600	600	1,100
Total	19,811	11,400	11,100	4,800
Basic mission operations and data analysis	(3,545)	(5,000)	(5,000)	(5,351)
Extended mission operations and data analysis	(1,794)	(2,000)	(3,700)	(8,549)
Atlas/Centaur (expendable launch vehicle program)	(5,200)	(---)	(8,300)	(---)

OBJECTIVES AND STATUS:

A major scientific objective of the HEAO program is to observe and investigate not only those X-ray sources that are already known, but also a much larger number which, either because of their distance or their low intensity, remained undetected before the advent of HEAO.

A product of this work, already underway with HEAO-1 and 2, has been the discovery of new classes of weaker X-ray sources, as well as the observation of the stronger sources outside our galaxy. Other equally important objectives include the observation of rare species of cosmic rays, which are crucial to our understanding of heavy element formation, and the observation of the nuclear gamma ray lines, which are important in understanding the origin of the elements. This program promises to advance our understanding of newly discovered processes that release extraordinary amounts of energy. It will also enhance our understanding of the creation of matter, and it will deepen our knowledge of observed phenomena such as quasars, pulsars, novae and supernovae.

The HEAO program consists of three missions utilizing Atlas-Centaur launch vehicles launched from the Eastern Test Range. HEAO-1, an X-ray survey mission, was successfully launched in August 1977. HEAO-1 results (discussed more fully under Mission Operations and Data Analysis) include the discovery of over 1,000 X-ray sources, as well as an isotropic plasma of many million degrees temperature. HEAO-2 was successfully launched in November 1978, and carries a grazing incidence X-ray telescope to make detailed studies of specific X-ray sources. The third mission (HEAO-C), to be launched in 1979, will carry a combination of cosmic ray and gamma ray instruments.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 estimate reflects a reduction in funding requirements for the HEAO-B spacecraft associated with the on-time, successful launch. These savings have been applied to extending HEAO-1 operations.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements will provide for the initial orbital operations of HEAO-C, continuation of the Guest Investigator program, support of HEAO-2, and the costs associated with the completion of the HEAO prime contract.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SOLAR MAXIMUM MISSION (SMM) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	17,600	8,600	8,600	---
Experiments	11,800	7,100	7,100	---
Ground operations	200	500	500	600
Total	29,600	16,200	16,200	600
Delta (expendable launch vehicles program)	(1,200)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The major objective of the Solar Maximum Mission (SMM) is to conduct detailed studies of the solar flare processes and the associated solar active regions during the next period of peak solar activity, which will occur in 1979 through 1981. The investigations will be conducted over a broad spectral range with high spectral, spatial and time resolution, and with the objective of explaining the underlying physical mechanisms and complex energy transfer and high energy particle acceleration processes involved.

To achieve the scientific objective, SMM will be launched near the period of maximum solar activity in order to observe a sufficient number of large and small flare events. Statistics, based on records of the past 19 solar cycles, show that a launch in late 1979 will assure that the spacecraft will be operating during the period of high solar activity. The study of flares is currently considered to be one of the most timely and important in the NASA solar physics programs, both by virtue of the significance of the phenomenon and by the state of readiness of the technology required to capitalize on the phenomenon. A great deal has already been learned about the flare process through instruments flown on OSO and Skylab. The SMM will be the first to make simultaneous observations over the necessary broad range of wavelengths.

In the area of solar terrestrial relationships, indications of a link between some form of solar activity (radiation, particles, and magnetic fields) and the Earth's weather and climate are increasing. With the basic capabilities of the flare payload, the inclusion of solar constant instrumentation, and the complementary International Sun-Earth Explorer research, the Solar Maximum Mission will make a significant contribution to our understanding of the effects of solar phenomena.

The procurement, assembly, and test of the experiments and spacecraft subsystems for SMM were basically completed in FY 1978. During FY 1979, the experiments and the spacecraft will be integrated. The observatory system will be tested, calibrated, and prepared for launch. The mission operations teams will be trained, and the guest investigator teams will be formed.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will provide for launch and the initial mission operations of the SMM observatory, for the work of the science experimenter teams, and for the initial data analysis.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SPACE TELESCOPE (ST) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Spacecraft	26,200	54,800	54,800	82,500
Experiments	9,800	24,400	24,400	30,200
Total	36,000	79,200	79,200	112,700
Space transportation system operations	(100)	(200)	(200)	(100)

OBJECTIVES AND STATUS:

The Space Telescope will make a major contribution to understanding the origin, evolution and scale of the universe; understanding the stars and galaxies, and the nature and behavior of the gas and dust between them; and developing a physical understanding of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase by several hundredfold the volume of space accessible for observations. With its significant improvements in resolution and precision, in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to investigate fundamental questions concerning the structure, the origin, the evolution, and the energy balance in the universe; these investigations could never be carried out using ground-based observatories due to the obscuring and distorting effects of the Earth's atmosphere. Its capabilities will open up to the astronomical sciences, and to science in the broadest sense, a road to new knowledge which will help shape our concept of the universe.

The Space Telescope will enable astronomers to study radiations in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater detail about the objects under study. It will make possible observations of objects so remote that the light will have taken many billions of years to reach us. As a result, we will be able to look far into the distant past of our universe. It will also contribute significantly to the study of the early stages of stars and the formation of solar systems; to the observation of such highly evolved objects as supernova remnants and white dwarf stars; and to other studies related to the origin and physical extent of the universe. With the Space Telescope, we may be able to determine the nature of quasars, and the processes by which they emit such enormous amount of energy. It will also be possible to study individual stars in nearby galaxies and perhaps to determine if nearby stars have planetary systems.

The Space Telescope will be an automated observatory, delivered into orbit in 1983 by the Space Shuttle. Data from its science instruments will be transmitted to oarth via the Tracking and Data Relay Satellite System. The ST will differ from existing automated satellites in that its design will permit in-orbit maintenance, repair, and retrieval by the Space Shuttle for return to Earth, refurbishment and reuse.

During FY 1978, design and development efforts were initiated. Contracts were awarded for the Optical Telescope Assembly and the Support Systems Module. During FY 1978, the contractors completed their planning, started preliminary design and initiated long-lead procurements. One of the most significant procurements was for two 2.4 meter diameter primary mirror blanks for the Optical Telescope Assembly. The contractors also completed negotiations with their major subcontractors for the focal plane structure, truss assembly, baffles, main ring, and the pointing control system. Project Requirements Reviews (by the observatory contractors) were conducted in February 1978. The Support Systems Module contractor is also actively involved with performing analyses necessary to ensure a totally integrated system. Scientific instrument contractors completed their planning and definition, conducted Project Requirements Reviews and initiated preliminary designs of instruments. Instrument development teams participated in the design of the instruments.

FY 1979 activities support continued progress in the Space Telescope design and development. The first primary mirror blank has been fabricated and shipped to the Optical Telescope Assembly contractor for grinding and polishing. Polishing of the mirror, which will be performed by a new computer-controlled polishing machine, is being demonstrated by polishing a 60-inch mirror to ST specifications. Polishing of the flight primary mirror is scheduled to begin in August 1979. A backup to the flight primary mirror will be fabricated and delivered in April 1979, for polishing, using traditional manually-controlled polishing machines. The observatory contractors will complete their preliminary designs leading to Preliminary Design Reviews in the last half of FY 1979. Detailed designs will be initiated following these reviews. The Preliminary Design Reviews for the Science Instruments will be conducted in early FY 1979, after which the payload selection will be confirmed and detailed instrument designs initiated. In addition, a contract will be awarded for the development of the command and data handling system for the scientific instruments, and for the preparation of the verification and acceptance activities associated with the instruments.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements will support detailed design and development of the Optical Telescope Assembly, the Support Systems Module, and Science Instruments. The Critical Design Reviews for these elements are scheduled for completion by mid-1980. After these reviews, fabrication and assembly activities will begin. Early in FY 1980, thermal/structural simulators of all the Science Instruments are scheduled to be delivered to Goddard Space Flight Center for development testing, using an early model of the focal plane structure provided by the Optical Telescope Assembly contractor. Final design and preliminary coding of flight software for the Systems Support Module will be completed in FY 1980.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

INTERNATIONAL SOLAR POLAR MISSION (ISPM) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	---	9,700	3,700	35,000
Experiments	---	3,100	9,200	14,000
Ground operations	---	200	100	1,000
Total	---	13.000	13.000	50.000
Space transportation systems operations	(---)	(100)	(100)	(6,700)

OBJECTIVES AND STATUS:

The International Solar Polar Mission is a joint NASA and European Space Agency mission designed to obtain the first view of the solar system from a new perspective -- a view from far above and far below the plane in which the planets orbit the Sun's equator. The two spacecraft will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, in order to gain insight into the possible effects of solar activity on the Earth's weather and climate.

The objective of the International Solar Polar Mission is to conduct an exploration of those regions of the heliosphere above and below the equatorial plane of the Sun. Observations in the extreme, high latitude regions of the Sun have not been made before, and evidence indicates that this region of space is greatly different from the region in which the Earth is located. Based on the growing evidence of a link between solar activity and terrestrial weather and climate, the need to understand the processes that might result from such a link becomes more pressing. The characteristics of the solar wind vary with the solar cycle, and the variability is becoming progressively better known as a result of continuing space exploration. The high latitude features on the Sun are believed to affect the solar wind conditions at Earth. The Solar Maximum Mission and the International Sun-Earth Explorers will study the solar process from essentially the solar equatorial plane.

An intensive study of the Sun-wind interface is now required in order to better understand the relationship of the solar cycle activity and solar wind conditions at the Earth. The International Solar Polar Mission, which will offer the first direct look at the third dimension of the Sun, will play a significant role in such a study. The eventual goal is to identify and to understand the influence of the Sun and solar activity on the space surrounding the Earth and, in turn, the influence of the Sun on the Earth and the other planets.

NASA and the European Space Agency will each provide one spacecraft of approximately equal and complementary capabilities. Science experiments have been assigned to each of the two spacecraft by a joint selection committee. Launch, tracking and data acquisition, and mission operations will be carried out by NASA, with European Space Agency (ESA) participation.

Employing a concept that exploits the gravitational pull of Jupiter, the launch of the mission is planned for February 1983. Both the NASA and ESA spacecraft will be launched from a single Shuttle/Inertial Upper Stage vehicle on a trajectory to Jupiter. The gravitational force of Jupiter will be used to swing the two spacecraft on mirror image courses (north and south) back over the Sun, well above the solar equatorial plane. Both spacecraft will then pass over the north and south poles of the Sun.

During FY 1979, the tentatively selected experimenters will be confirmed, flight instrument design will begin and interface specifications will be established, and the spacecraft system contractor will be selected.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 funding requirements for the ISPM project development remain the same as the budget estimate. The redistribution between the spacecraft and the science project elements is based on receipt and review of the experiment proposals and is consistent with scheduling of the overall project milestones.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will provide for continued development of experiment hardware and the initiation of a contract to industry for the spacecraft system. Activities in the spacecraft contract are expected to include detailed system design, subsystem contracts, and electronic parts procurement.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SHUTTLE/SPACELAB SCIENCE PAYLOAD DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Science and equipment development	19,361	27,800	21,100	29,900
Integration and operations	7,700	10,500	13,800	11,400
Total	27,061	38.300	34.900	41.300
Space transportation systems operations	(---)	(7,900)	(7,900)	(20,100)

OBJECTIVES AND STATUS:

The objective of the Shuttle/Spacelab Science Payload Development program is to advance scientific research in the major disciplines of astrophysics, solar physics, space plasma physics, and astronomy by capitalizing on the unique capabilities of the Space Shuttle and Spacelab. The science payload development activities will provide for the design, development, and integration of experiments and special supporting subsystems to be flown on Shuttle orbital flight test and Spacelab missions. The efforts will also include provision for payload mission operations and data analysis.

Shuttle Orbital Flight Test (OFT) and Spacelab 1 and 2 Payload Development

Development activities for the experimental payloads to be flown on a Shuttle orbital flight test are proceeding well. All the instrument Critical Design Reviews have been completed and flight hardware is in fabrication. The design of instrument support systems will be completed in early 1979. Spacelab 1, a joint undertaking by NASA and the European Space Agency, is planned for launch in late 1981, followed by Spacelab 2 in 1982. The primary objective of the first mission is the verification of the Spacelab performance and capabilities. The secondary objective is to obtain scientific, applications, and technology data. For Spacelab 1, a total of 42 (17 NASA and 25 ESA) investigations were selected for definition studies in early 1977, and for Spacelab 2, thirteen investigations were selected in mid-1977, for definition studies. The definition studies have provided a deeper technical and programmatic understanding of the individual investigations and of the system function of the entire complement of instruments. After completion of the definition studies in 1978, an assessment of the capabilities of the experiments and a confirmation for flight were made.

The Payload Specialist training for Spacelab 1 began in August 1978, and the specialists have been actively involved with the project for the last several months. Initial design evaluations of the Spacelab 2 instruments have been completed and several of the instruments have now commenced fabrication. Initial design evaluation of the mission-unique equipment has also been completed. Payload specialists for Spacelab 2 have been selected.

Shuttle/Spacelab Principal Investigator and Multiuser Payloads

Payloads to be flown on the Shuttle and Spacelab are divided in two classes: Principal Investigator (PI Class) Instruments, and Multiuser (MUI Class) Instruments. PI Class Instruments are instruments that are proposed for a specific scientific investigation by a single investigator who may have co-investigators. MUI instruments have a broad scientific capability, can accommodate a number of PI-furnished focal plane or ancillary instruments, and have a large user community. In general, PI Class and MUI Class instruments will fly together, making scientifically focused payloads. An Announcement of Opportunity was issued in 1978, soliciting proposals for investigations to be conducted on post Spacelab 3 missions. In response to the Announcement of Opportunity, approximately 200 proposals were received and will be evaluated in early 1979. The selection of PI experiments will be made in the spring of 1979, and development of the instruments will begin in late FY 1979.

During FY 1979 work will proceed on development of the solar optical telescope and the chemical release module. The solar optical telescope will allow high resolution observations of the solar surface features using a number of focal plane instruments. The system will be designed for changes of focal plane instrumentation between successive flights. The chemical release module will be used to trace the atmospheric motions of neutral constituents, to map out magnetic and electric fields, to display plasma instabilities and to study, using test particles, particle behavior. The Shuttle Infrared Telescope Facility, the subject of conceptual studies, will be designed to perform high resolution studies of star formations and other astronomical features utilizing six focal plane instruments. It will employ super-cooled structure and detector systems to study infrared sources and phenomena invisible to other ground-based and spaceborne systems.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $3.4 million in the FY 1979 estimate is the result of the Congress' general reduction in NASA's R&D appropriation, and the rephasing of funding requirements consistent with the delay in planned Spacelab missions. To prepare for the initial Principal Investigator and multiuser flights, the FY 1979 funding for integration was increased to establish the integration capability.

BASIS OF FY 1980 ESTIMATE:

Shuttle Orbital Flight Test (OFT) and Spacelab 1 and 2 Science Payload Development

During FY 1980, OFT science instrumentation will be completed and integrated. Test and final evaluation of the instruments will be undertaken. The science mission design and mission software activities will continue, leading to a late 1980 flight. The Spacelab 1 and 2 instruments will continue in fabrication and test. Software and mission design activities will also continue.

Shuttle/Spacelab Principal Investigator and Multiuser Payloads

FY 1980 funding will provide for continued development of the selected Principal Investigator instruments and the mission-unique activities necessary for the first multidisciplinary flight in 1982. The FY 1980 funding will also continue the development of the Solar Optical Telescope and the Chemical Release Module. During FY 1980, system studies will be completed for the Shuttle Infrared Telescope Facility to prepare for development beginning in FY 1981.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

EXPLORER DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
International sun-earth explorers (ISEE)	3,021	---	---	---
Dynamics explorer (DE)	5,300	12,800	13,800	11,100
Solar mesosphere explorer (SME)	1,419	5,000	2,100	6,900
International ultraviolet explorer (IUE)	807	---	---	----
Infrared astronomical satellite (IRAS)	11,500	10,500	10,200	5,700
Other explorers	2,250	1,500	3,700	6,700
Total	24,297	29,800	29,800	30,400

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Mission operations and data analysis	(10,703)	(12,200)	(12,200)	(13,000)
Scout and delta (expendable launch vehicles program)	(11,400)	(3,500)	(9,200)	(---)
Space transportation system operations	(---)	(---)	(---)	(3,700)

OBJECTIVES AND STATUS:

The Explorer program, comprised of a number of individual projects, provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment which do not require observatories.

Included in the present program are missions to study atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; and X-ray, ultraviolet, and infrared astronomy.

Studies are conducted to define future high priority science Explorer missions. NASA engages in co-operative missions with other U.S. Government agencies and other nations whenever such cooperation will assist in achieving NASA objectives. The Explorer program supports both the Solar Terrestrial and Astrophysics programs.

Solar Terrestrial and Atmospheric Explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere, to the interplanetary medium beyond the Earth's magnetosphere. The Solar Terrestrial program is in a transition from the early discovery and mapping phase conducted over the past decade to a phase in which specific problems will be investigated in more depth. For example, the cause and effect interactions of the fluctuating solar wind on the Earth's environment are being studied by means of simultaneous measurements at different locations by projects such as the International Sun-Earth Explorers (ISEE), a cooperative effort with the European Space Agency. The ISEE A and B spacecraft were successfully launched in October 1977. ISEE C was successfully launched in 1978 and placed in a halo orbit between the Sun and Earth on November 20.

More efforts underway include development activity for the Solar Mesosphere Explorer, the Dynamics Explorer, and the San Marco-D missions, the latter a cooperative program with Italy. The Solar Mesosphere Explorer will be designed to investigate the stability of the Earth's ozone layer with emphasis on determining the response of ozone to changes in the solar ultraviolet flux. Definition studies for several missions are underway, including the Active Magnetospheric Particle Tracer Explorer (AMPTE), a cooperative program with the Federal Republic of Germany, with development activity anticipated in FY 1980 or FY 1981.

Astrophysics Explorers provide the means for carrying out astronomical studies which do not require large, complex observatories. Included in the program are the International Ultraviolet Explorer, which is a cooperative effort with the United Kingdom and the European Space Agency; and the Infrared Astronomical Satellite, a cooperative program with the Netherlands and the United Kingdom. The International Ultraviolet Explorer mission was successfully launched in January 1978. Astrophysics Explorers have been instrumental in initiating comprehensive astronomical studies in the X-ray, gama ray and low frequency radio regions of the electromagnetic spectrum. Major efforts underway include continuation of hardware and subsystems procurement and experiment fabrication for the Infrared Astronomy Satellite; continuation of development work for the Cosmic Ray Isotope Experiment (CRIE), a cooperative program with DOD in which NASA will provide a scientific instrument for flight on an Air Force spacecraft; and future mission definition studies including the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EUVE) with development to be initiated in FY 1980 or FY 1981.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current estimate for the total Explorer program remains the same as the FY 1979 budget estimate. The redistribution of funds within the Explorer program reflects the revised schedule for the SME which permitted increased development activity on the Dynamics Explorer project and definition effort on other Explorers during FY 1979.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will provide for continuation of hardware and subsystem procurement and experiment fabrication for the Infrared Astronomy Satellite Explorer, the Dynamics Explorer and the Solar Mesosphere Explorer; initial development activity for one or more of the Explorers - AMPTE, COBE, EUVE; continuation of work on CRIE and the San Marco-D mission; and definition studies for future Explorer missions.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
High energy astronomy observatory (HEAO)	5,339	7,000	8,700	13,900
Solar maximum mission (SMM)	---	---	---	4,900
Space telescope (ST)	---	---	---	1,800
Orbiting explorers	10,703	12,200	12,200	13,000
Orbiting astronomical observatory (OAO)	1,956	2,600	2,600	2,900
Orbiting solar observatory (OSO)	1,300	1,500	1,500	---
Total	19.298	23.300	25,000	36,500

OBJECTIVES AND STATUS:

The purpose of this effort is to conduct operations and to analyze data from the Physics and Astronomy satellites after launch. Since a number of spacecraft have survived beyond their originally planned lifetimes, operations are continued for specific investigations that have high scientific potential.

In-orbit operations and data analysis activities in support of HEAO-1 and HEAO-2, launched in August 1977 and November 1978, respectively, are underway. HEAO-1 has completed nearly 18 months of successful operation. One of the major results obtained from HEAO-1 has been the discovery of a very thin, hot, plasma that appears to extend throughout the universe. This plasma may contain enough mass to close the universe, which implies an eventual contraction of the universe followed by a repeat "Big Bang" beginning. Precise celestial positions for about 100 X-ray sources have been determined, leading to new identification of the optical counterparts of these sources. The X-ray sky survey experiment on HEAO-1 has completed 2 1/2 complete scans of the sky for new X-ray sources. About 1/6 of the data have been reduced and indicate that the detection of well over 1,000 new X-ray sources will be achieved. The HEAO-1 data contains such a wealth of information that continued analysis for several years will be required to extract all of the scientific knowledge contained therein. HEAO-2 is presently undergoing on-orbit instrument checkout. All systems are performing excellently and we have every expectation that HEAO-2 will also make major scientific contributions. The Solar Maximum Mission will be launched in late 1979 with mission operations beginning in FY 1980.

Although the primary thrust of the Mission Operations and Data Analysis program involves operational satellites already in orbit, the Space Telescope program presents several unique features which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, based on in-orbit maintenance, recovery, refurbishment, and relaunch and in-orbit changeout of the focal plane scientific instruments. During the operational period, it will be used the majority of the time by general observers scheduled on the basis of proposals submitted in response to periodic solicitations. Observing schedules will integrate these requirements with those of investigators who are involved with development of focal plane instruments. NASA has determined that the most efficient and scientifically satisfactory approach to science operations will involve establishment of an independent Science Institute which will operate under a long-term contract with NASA. While NASA will retain operational responsibilities for the observatory, the Institute will implement NASA policies in the areas of planning and management and scheduling of the scientific operations of the telescope.

A number of Explorer class spacecraft remain operational and continue to provide valuable and interesting scientific data. Analysis of these data have led to a number of significant new findings. For example, astronomers using the International Ultraviolet Explorer have discovered acetylene in the atmosphere of Saturn. This compound is an important starting material in the synthesis of many organic compounds. The IUE has also provided data which indicate that stars much cooler than our Sun possess solar-type winds which are so intense that a normal corona cannot develop. Further studies of these enhanced stellar winds should provide a better understanding of the solar phenomenon itself. Mass flow on very large scales has also been observed in several X-ray binary systems. Large amounts of mass have been detected flowing from the normal type stars in these systems toward the neutron or black hole components. The Small Astronomy Satellite (SAS-3) has recently detected X-rays from two quasars (one of these objects is the closest quasar ever discovered). These observations add quasars to the growing list of energetic X-ray sources in the sky. Finally, the Atmospheric Explorer (AE) has provided valuable data which have aided in the understanding of the forces contributing to the re-entry of Skylab.

OAO-3 (Copernicus), which was launched in 1972, is providing a three-axis stabilized automated facility for observing celestial objects and interstellar material in the X-ray and ultraviolet spectral ranges. OAO-3 is the only currently operating or planned satellite capable of making spectroscopic observations in the important 900-1,150 angstrom wavelength region. During the past six years, new techniques have been developed which have enhanced the usefulness of OAO-3 by allowing the observation of objects six times fainter than could be observed when the satellite was first launched. As a result, many new classes of objects can now be studied by this observatory. FY 1979 funds support the operation of OAO-3 and the analysis of data obtained. Support is also being provided for guest investigators from universities, government institutions and several foreign countries. The program has involved over 160 investigators and 170 different scientific projects.

The operation of OSO-8 was terminated on September 30, 1978, after 3 1/2 years of successful operations, and FY 1979 will be the final year of data analysis for this mission. Major accomplishments in solar physics concern refined temperature models of the Sun's atmosphere from the temperature minimum up through the chromosphere, detection of impulsive brightenings in the transition zone that may represent the smallest extreme of flare processes, and detailed investigation of the heating of the lower chromosphere by short period waves. The stellar high energy experiments measured for the first time polarization in Cygnus X-2, indicative of a magnetic field, and the crystal spectrometers found spectral lines from ions in Cygnus X-3. The interstellar gas photometer was used to make a detailed model of the interstellar neutral gas (hydrogen and helium) that is streaming through our solar system. A symposium will be held in July 1979, at the Goddard Space Flight Center, to summarize the results of OSO-8. The accomplishments of OSO-8 have brought the physics and Astronomy program a considerable distance toward the objective of understanding the intricate functions of the Sun in the Solar Terrestrial relationship.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 change reflects an increase of $1.7 million in the mission operations and data analysis phase of the HEAO program in order to extend the operations of the highly successful HEAO-1 mission.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will provide support for the continued operation of the HEAO-2 mission and related data analysis activity; extension of operations and data analysis activity for OAO-3, SAS-C, IUE, ISEE-A, B, and C, and AE-E. FY 1980 funding will also support the operations and data analysis activities of the HEAO-C mission and the Solar Maximum Mission (SMM), as well as initiation of preparations for science operations for the Space Telescope, including the initiation of a Space Telescope Science Institute.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology (SR&T)	16,841	19,300	19,300	21,500
Spacelab science payload definition	4,000	4,100	4,100	3,200
Advanced technological development	2,066	---	---	2,500
Data analysis	8,427	9,100	9,100	7,100
Upper atmospheric research	11,600	11,900	11,900	---
Search for extraterrestrial intelligence	---	600	---	---
Total	42,934	45,000	44,400	34,300

OBJECTIVES AND STATUS:

This program provides for the research and technological base necessary to plan and support flight projects. Preliminary studies to define missions and/or payloads requirements are carried out, as are theoretical and ground-based supporting research, and Advanced Technological Development (ATD). Activities included are Supporting Research and Technology (SR&T), Spacelab Science Payload Definition, ATD, and Data Analysis. Beginning in FY 1980, the Upper Atmospheric Research program and directly supporting activities will be included in the Space Applications.

Supporting Research and Technology (SR&T)

The objectives of Supporting Research and Technology are: (1) to enhance the value of current space missions by carrying out supplementary ground based observations and laboratory experiments; (2) to develop theories to explain observed phenomena and predict new ones; (3) to optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions and (4) to strengthen the technological base for sensor and instrumentation development and to conduct basic research necessary to support our understanding of Astrophysics and Solar Terrestrial relationships.

Research is supported in several disciplines of space physics and astronomy. The work in space physics is largely devoted to tasks related to the physics of the Earth's environment and comparative studies of other planetary environments, including the study of Sun-Earth environmental factors. The work in solar physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary and planetary environments. Research supported in astrophysics involves studies of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The development of new instruments, laboratory and theoretical studies of basic physical processes, radio observation of solar and galactic processes and observations by ground-based and balloon-borne instruments are also supported.

A major activity in SR&T is theoretical study which provides a balanced research program in Solar Terrestrial physics. As the exploratory phase of research ends and a more mature research phase which seeks consolidated understanding begins, theory must be strengthened to be a healthy and viable partner with experimentation in the quest for detailed physical understanding. Theory integrates a coherent set of hypothetical, conceptual, and programmatic principles forming the general frame of reference. As such, theory can provide the consolidation of empirical and theoretical knowledge necessary for future mission planning to ensure maximum return from future measurement projects.

The FY 1980 budget request is fully consistent with the 1978 recommendations of the Committee on Space Physics of the Space Science Board which determined that "The theoretical component of the space-plasma-physics effort needs to be strengthened by increased support and, most particularly, by encouraging theory to play a central role in the planned development of the field."

During FY 1979, the SR&T program will fund tasks at universities, non-profit and industrial research institutions, NASA Centers, and other government agencies. Current emphasis is being placed on advanced research pertaining to IR detector devices, X-ray imaging devices, and spectrometers.

Spacelab Science Payload Definition

Spacelab Science Payload studies have provided the data necessary to establish a sound foundation for the Physics and Astronomy experiments to be conducted on Shuttle/Spacelab missions, The initial studies concentrated on establishing the feasibility of performing discipline-dedicated missions and multidiscipline missions employing both facility-class and principal investigator-class instrumentation. The studies have identified the benefits which can be realized by re-flying instruments and facilities and have also established the feasibility of Shuttle-borne research laboratories and experiments. The Spacelab Science Payloads will employ many common, reusable facility-type and investigator-class instruments to study phenomena in all astronomy and space physics discipline areas.

Several Multiuser Class instruments have been endorsed by a scientific review committee for flight consideration on future missions. Among the candidate instruments are: Large Area Modular Array (LAMAR), which will provide very high time resolution studies of variable X-ray sources; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class general purpose facility capable of accommodating a wide variety of PI-type instruments.

During FY 1979, further definition involving detailed descriptions of instruments, payload configurations, and operational mission profiles is continuing.

Advanced Technological Development

The Advanced Technological Development (ATD) activities will support planning and definition of new and more advanced science missions in Physics and Astronomy based on careful scientific planning performed together with senior advisory bodies. The project will provide the basis for incorporating emerging technologies and evolving science concepts with scientifically planned Physics and Astronomy missions. After identification of the technology and science requirements, science and spacecraft systems feasibility will be evaluated. Funding will be applied to definition and preliminary design of subsystems and elements critical to eventual mission development, in order that technical readiness and resources may be better known before the missions are proposed for implementation.

Candidate missions for the 1980's that will benefit from the ATD project include Gamma Ray Observatory (GRO), Origin of Plasmas in Earth's Neighborhood (OPEN), the Advanced X-ray Astronomy Facility (AXAF), the Gravity Probe-B (GP-B), and the Solar Probe. The GRO will study the basic physical processes of the universe. From this mission will come fundamental knowledge of the forces that shape the cosmos. The AXAF will study stellar structure and evolution, large scale phenomena, active galaxies, clusters of galaxies and cosmology. The AXAF 1.2 meter class telescope will be capable of a sensitivity approximately 20 times that of HEAO-2. The GP-B will be utilized for carrying out an experimental test of Einstein's General Theory of Relativity in which measurements will be obtained of the relativistic precision of an extremely stable, cryogenic gyroscope in Earth's orbit. The OPEN project will be designed to trace the flow of matter and energy from input by the solar wind to output into the atmosphere; to understand storage and acceleration of plasma in the Earth's neighborhood; and to determine the importance of these phenomena and their variability in our delicately balanced environment. The Solar Probe mission will perform detailed scientific observations of the Sun from a small diameter solar orbit, eventually probing the Sun at mission end.

Data Analysis

Activities supported in this area include the analysis of data acquired from instruments flown on spacecraft, balloons, sounding rockets, and research aircraft as well as from ground-based observatories, with emphasis on correlative studies involving data acquired from several sources. To study given phenomena over an adequate range of important independent variables, it is necessary to process large quantities of data covering extended periods of time. Thus, additional data is processed and analyzed, multi-instrument studies are made, and various proposed models or theories are critically tested by use of the data.

Support for the operation of the National Space Science Data Center (NSSDC) is also provided under this program. The NSSDC, located at the Goddard Space Flight Center (GSFC), was established to serve as a central repository and clearing house for scientific data resulting from space investigations. The Satellite Situation Center at NSSDC computes the expected positions of operational spacecraft, so that data acquisition and analysis efforts can be concentrated at times when several spacecraft are especially favorably situated for correlative geophysical studies. The Skylab ATM data analysis program is currently in its final year. The analyses to date have influenced nearly every aspect of solar physics. In the case of at least one topic (coronal holes), the subject has been greatly expanded as a result of these analyses. The third Skylab Workshop, on Active Regions, is in progress and will, like its two predecessors on Coronal Holes and Flares, result in a published monograph.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 Research and Analysis funding has been reduced by $600 thousand because of the elimination by the Congress of the proposed search for extraterrestrial intelligence research project.

BASIS OF FY 1980 ESTIMATE:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Supporting Research and Technology	16,841	19,300	19,300	21,500

During 1980, emphasis in the supporting research and technology area will be given to those tasks which are critical to maintaining a firm base for a viable Physics and Astronomy program. Special emphasis will be placed on studies for advanced instrumentation which will increase both the sensitivity and resolution of detectors. The goal of these programs is to increase the efficiency and precision of data acquisition in all regions of the specturm. Feasibility and scientific definition studies will be conducted on several potential candidate missions for future years.

In solar physics, ground-based solar optical and radio flare observing programs to complement the Solar Maximum Mission have been organized. Additional ground-based solar velocity field measurements will be made, to expand the new and exciting results obtained so far on the solar convection and circulation processes and on probing the convective envelope of the Sun. Several new efforts based on the theory of solar flares have been started which will help corroboarate the results expected from SMM. Two balloon payloads for the observation of gamma-rays from solar flares will be flown.

Space plasma physics research places increased emphasis on research to predict the interaction of the different space particle and field regimes, including instabilities that cause ionospheric irregularities and those that result in the acceleration of particles in auroral regions and generation of terrestrial kilometric radiation. More work will be devoted to study of instruments to be employed using the Shuttle/Spacelab as a laboratory in space to perform active, controlled experiments by perturbing the plasma medium with a known stimulus and detecting the response. In Astronomy, work will continue on the development of advanced detectors for future space astronomy missions. In support of the data analysis activities of the International Ultraviolet Explorer (IUE), emphasis will be placed on the theoretical and ground-based observational studies of stellar chromospheres and coronae which are the subjects of a substantial number of the IUE Guest Investigator programs. Studies in infrared astronomy will continue to concentrate on the theories of star formation and the physics of cool, dense, interstellar clouds; as part of this effort, there will be an emphasis placed on observing programs from the southern hemisphere using balloons, airplanes and ground-based telescopes.

The FY 1980 budget request for SR&T will also permit the implementation of the theoretical effort by calling upon university, industrial, and government scientists to develop the necessary base on which to further our understanding of the fundamental physics at work in the solar terrestrial relationship. By developing the theoretical base, NASA will be able to define more precisely the science of the 1980's. The solar terrestrial theoretical activities will be directly supportive of the Physics and Astronomy objective of understanding the interaction of the Sun and the Earth's plasma by establishing the clearly defined point for the consolidation of the knowledge necessary for planning.

In high energy astrophysics, instrument work is directed toward the development of new solid state X-ray imaging devices and crystal spectrometers for use on Spacelab and on future high energy astrophysics free flyer missions. New cosmic ray detectors employing the principle of transition radiation are being developed in order to reach into the unexplored high energy cosmic ray region. Important testing of these instruments is carried out on balloons and sounding rockets.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Spacelab Science Payload Definition..........................	4,000	4,100	4,100	3,200

In FY 1980, further payload definition of new concepts and of those presently under study will be performed. The studies will provide descriptions of instruments and facilities, payload configurations and operational mission profiles. In addition, concepts and methods of extending time in orbit beyond the present Spacelab capability are being studied and evaluated. The detailed scientific definition of those facility instruments that are strong candidates for hardware development in the early 1980's will be carried out in N 1980.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Technological Development (ATD)	2,066	---	---	2,500

FY 1980 funding will provide for continuation of studies and definition of future missions planned for the 1980's. The FY 1980 ATD funding will allow for the further definition study of the Gamma Ray Observatory (GRO) scientific instrumentation and the advanced development of the gamma ray sensors. Major emphasis will also be on ATD for the Origin of Plasmas in Earth's Neighborhood (OPEN), the Advanced X-ray Astronomy Facility (AXAF), the Gravity Probe-B (GP-B), and the Solar Probe. Within the FY 1980 funding, contractor definition studies will be accomplished to assure the technological and scientific readiness of the candidate future missions.

Data Analysis.	8,427	9,100	9,100	7,100

Emphasis in the Data Analysis project, to be carried out at universities and government research centers, will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft, and ground observatories). FY 1980 funds will also support the operations of the National Space Science Data Center.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SUBORBITAL PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Sounding rockets.	19,899	22,200	22,200	21,700	4-26
Airborne research	3,800	4,600	4,600	4,000	4-27
Balloon program....	1,500	2,500	2,500	1,200	4-28
Total.	25.199	29.300	29.300	26,900	

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Sounding Rockets.	19,899	22,200	22,200	21,700

OBJECTIVES AND STATUS:

The Sounding Rocket program provides a versatile, relatively low cost tool for scientific research in the suborbital space environment. This program provides broad-based support of all of the scientific disciplines, including the study of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis. The current level of activity is approximately 60 rocket flights per year.

The specific objectives of the Sounding Rocket program are as follows:

1. To conduct a coordinated research program with flight requirements that cannot be met by vehicles with different performance characteristics such as balloons, aircraft and satellites and that do not require long duration satellite observation. Specific areas of study include:

   a. The nature, characteristics, and composition of the magnetosphere and near space.

   b. The effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere.

   c. The nature, characteristics, and spectra of radiation of the Sun, stars, and other celestial objects.

2. To support the basic objectives of the Physics and Astronomy program by providing the means for flight testing instruments and experiments being developed for flight on satellites, observatories, and space probes; and for calibrating or obtaining vertical profiles in correlation with current orbiting spacecraft.

During 1978, 60 rockets were launched from seven locations in the United States, Canada, Sweden, Norway, Greenland, Australia, and Antarctica. These rockets supported the research activities of more than 50 groups from universities, private industry, NASA field centers, other government agencies and foreign space organizations. Soviet and U.S. rockets were fired from Wallops Flight Center (WFC) in the Joint American-Soviet Particle Intercalibration Experiment with the prime objective of determining the source of the nighttime erosion in the ionosphere.

In Space Plasma Physics, rockets are primarily used for low altitude measurements, vertical profiles and chemical release, none of which can be performed with satellites. Increasing emphasis is being placed on investigating the mechanisms that accelerate particles in the auroral regions.

The Solar Physics sounding rocket program continues to play a major role in the NASA solar program. Activities during 1978 included selection of a launch site for conducting sounding rocket flights during the 1980 solar eclipse over East Africa. During FY 1979, the refurbishment of a payload for those flights is scheduled for completion. From late 1979 through 1980, an aggressive program of flights which will observe the Sun by X-rays is planned in support of the Solar Maximum Mission.

In the astronomy area, continuing emphasis is being placed on development of instruments for measurements of stars and extended sources in both the ultraviolet (UV) and X-ray spectral regions, and on correlative measurements of the same objects in different portions of the electromagnetic spectrum. Of special interest during 1978 was the series of seven sounding rocket flights from the launch site at Woomera, Australia, which made X-ray and UV observations of objects in our galaxy and in certain nearby galaxies which can only be viewed from the Southern Hemisphere. During FY 1979, the first flight test of a negative electron affinity X-ray imager is planned.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will provide for continuation of most of the efforts described above. Emphasis is being placed on the 1980 solar eclipse over East Africa, the coordination of near-simultaneous launches of several rocket payloads, on correlation with satellite observations, and on flights flown to make measurements, such as those that depend upon film for data recording, which cannot be made with existing satellites.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Airborne Research	3,800	4,600	4,600	4,000

OBJECTIVES AND STATUS:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in Physics and Astronomy since 1965. The aircraft platform provides a large payload capacity and facilities for extending observations over any region of the Earth. It also may be transported readily to high operational altitudes, near 15 km (50,000 feet) in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this cloud-free altitude has been essential in opening to astronomy the infrared region of the electromagnetic spectrum from one micrometer to one millimeter. The airborne platform has the further advantage of enabling scientists to participate directly in space research.

The Airborne Research program has utilized two aircraft, the C-141 instrumented with the 91-cm infrared (IR) telescope and the Lear Jet instrumented for unique individual missions.

The C-141A "Kuiper Airborne Observatory", which began operational flights in 1974, is a full-scale, manned facility. The 91-cm f/13.5 IR telescope operates through an open port, with a pressure bulkhead giving the astronomers a comfortable, shirtsleeve environment in which to work. The telescope floats on a large air bearing that permits hours of accurate stabilization within a few arc seconds. The weight of this observatory is about 16 tons (14.5 metric tons).

During the past year, one of the principal scientific accomplishments was the detection of the first infrared "Bok Globule". These globules are very small dark clouds in our galaxy which appear as black spots on photographs and up to now have been opaque to any radiation. This detection opens up a whole new class of objects that can now have this emission measured directly. During 1979, support will be provided for the February 1979 solar eclipse over the Northwestern United States and Canada and for an expedition to lower latitudes to observe the Galactic Center. In addition, provision has been made for a scheduled airframe inspection for the C-141A.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, Airborne Research funds will be used to continue operations of the Airborne Observatory. Funds will also be applied to support for astronomical groups, acquisition of subsystems, and operations with the Lear Jet.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Balloon Program	1,500	2,500	2,500	1,200

OBJECTIVES AND STATUS:

For the development of scientific experiments for spaceflight and for independent scientific missions, it is necessary to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly in X-ray and infrared parts of the electromagnetic spectrum. In many instances, it is least expensive to fly these experiments on balloons. The funding for this program is utilized for balloons, helium, launch services, tracking and recovery, while funding for the experiments is provided from the Supporting Research and Technology program.

During 1978, approximately 50 balloons were flown from 11 global sites to support the research activities of approximately 35 organizations. This included a flight over Alice Springs, Australia, which acquired information that confirmed the existence of gamma ray emissions from the galactic center. A narrow gamma ray line was observed at 512 KeV, which is caused by the annihilation of electrons and positrons. Until this observation, there had been no unambiguous evidence for a steady non-solar gamma ray line. The launch of approximately 10 heavy-lift balloons had to be postponed during 1978 due to *two* consecutive failures. A recovery plan has been initiated and a decision concerning the resumption of heavy-lift balloon flights will be made around mid-February 1979. The FY 1979 funding provides support for approximately 60 flights assumming successful resolution of the program involving heavy-lift balloons.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding provides for continuation of the balloon program with some reduction in the number of heavy-lift balloon flights.

PLANETARY
EXPLORATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE | PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Pioneer Venus	17,900	---	---	---	---
Galileo	20,950	78,700	78,700	116,100	5-4
Mission Operations and Data Analysis	64,359	59,300	59,300	59,000	5-6
Research and Analysis	43,991	49,100	44,400	45,100	5-8
Total	147,200	187,100	182,400	220,200	

Distribution of Program Amount by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Johnson Space Center	8,717	8,470	4,356	6,380
Marshall Space Flight Center	79	---	2,488	10
Goddard Space Flight Center	3,041	2,410	3,359	3,830
Jet Propulsion Laboratory	74,100	110,890	107,675	136,330
Ames Research Center	27,288	39,400	38,805	44,520
Langley Research Center	11,000	---	---	---
Lewis Research Center	80	---	---	---
Headquarters	22,895	25,930	25,717	29,130
Total	147,200	187,100	182,400	220,200

OFFICE OF SPACE SCIENCE PLANETARY EXPLORATION PROGRAM

LAUNCH SCHEDULE

Project	Mission	Calendar Year
Galileo	Galileo	1982

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Planetary Program includes scientific exploration of the planets and their satellites, the Moon, the small bodies (comets and asteroids), interplanetary dust, and the charged particles and electromagnetic fields of interplanetary space. The program objectives are to understand the present state, origin and evolution of the solar system, to better understand the Earth through comparative planetological studies, and to understand the relation of the chemical history of the solar system to the origin and evolution of life. The program has been highly successful, with the reconnaissance phase of inner planet exploration now complete and with excellent progress in extending our exploration to the outer planets. The depth of the exploration effort is being increased with more detailed investigation of the inner planets underway and the breadth is ready to be extended to cometary and asteroid exploration. The inner planet exploration was established by Mariner-class missions to Mars, Venus and Mercury. As a result of the Apollo missions and the continuing data analysis, lunar exploration is providing fundamental insights into our solar system's origin and planetary evolution. The Viking mission to Mars has provided both a deepening of our understanding of this planet and a leap forward in our technical capabilities. The Pioneer Venus mission is taking exploration of our nearest planetary neighbor into a new era, especially in terms of atmospheric investigations. The four Pioneer Venus probes and the transporter spacecraft entered the atmosphere of Venus on December 9, 1978, and returned a large volume of high quality data that are now undergoing detailed analysis. The Pioneer Venus orbiter was successfully inserted into Venus orbit on December 4, 1978, and will continue to return valuable data for months.

Outer planet exploration, begun several years ago when Pioneers 10 and 11 flew by Jupiter, will be given a major impetus in 1979 by two Voyager spacecraft flybys of Jupiter and by the Pioneer 11 flyby of Saturn. The two Voyagers will continue on to Saturn for 198011981 encounters and the second spacecraft could then proceed to Uranus for a 1986 encounter.

Pioneer 10 will soon be beyond the orbit of Uranus and is moving inexorably out of our solar system. It is gathering unique data about the outer portions of our solar system and searching for the transition between interplanetary and interstellar space. Pioneers 6-9 and Helios 1 and 2 remain in good condition orbiting the Sun and periodically returning data about the interplanetary medium in the inner solar system. FY 1980 funds will support the extended missions of Pioneer 6-11, the Pioneer Venus Orbiter, Helios 1 and 2 and the cruise operations of the Voyagers moving on to Saturn.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany, which will carry forward the exploration of Jupiter and its satellites. Launch is planned for January 1982, using the Space Transportation System. Science experiments have been selected from within the United States and from Europe. In the last year, progress has been made and the development effort is proceeding on schedule. FY 1980 funds will be used to continue this development effort.

Strong research and analysis programs continue to provide both a basic framework for the Planetary Program and a coordinated effort of analysis to take full advantage of the data that have already been acquired. These programs involve many different types of effort, including data and sample analysis, telescopic observations, theoretical and laboratory studies, and the definition of instruments needed for future missions. Many of the achievements of the Planetary Exploration program came from the research and analysis programs where all ideas are subject to intense scrutiny, and where the close association of the various research groups leads to the rapid dissemination of new concepts. Research using lunar samples, meteorites and cosmic dust remains a key element of the Planetary Program. The lunar sample effort is mission-oriented and is coordinated with lunar sample research funded by the National Science Foundation. These research programs are closely associated with the planning efforts to define the scientific rationale and the technology needs for future planetary program flight missions.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

GALILEO

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	11,660	55,900	53,470	83,260
Experiments	7,590	22,000	19,374	24,266
Ground operations	1,700	800	5,856	8,574
Total...	20,950	78,700	78,700	116,100
Space Transportation System Operations	(900)	(5,500)	(5,500)	(16,900)

OBJECTIVES AND STATUS:

The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance and orderly progression of our program of exploration of the solar system.

The objectives of this program are to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere and satellites by a single mission, utilizing a new deep space spacecraft concept which combines both remote sensing and direct measurements on a combined three-axis stabilized/spinning spacecraft with an atmospheric probe.

The orbiter/probe combination will be launched in January 1982, by the Space Transportation System. The entry probe, designed to survive a descent to a pressure of at least 10 Earth atmospheres, will be separated from the orbiter prior to the Jupiter encounter. Scientific data gathered by the probe during entry will be relayed to Earth via the orbiter. Shortly thereafter, the orbiter will be inserted into orbit around Jupiter and the orbit will be periodically adjusted to permit multiple encounters of the satellites of Jupiter.

In FY 1979, the design, development and fabrication activities will proceed. Requirements imposed by the science and design of the mission are being translated into designs for the major elements of Galileo--the probe and orbiter spacecraft, the mission operations, the spacecraft propulsion module, the on-board power systems, and the Space Transportation System interface.

CHANGE FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 Galileo estimate remains unchanged in total; however, adjustments have been made within the project elements. These adjustments are of two types, both based on experience with the Voyager project: (1) the Ground Operations estimate was increased by approximately $3.0 million to reflect a functional transfer of certain responsibilities for mission-wide engineering activities (data system) and for preparation of flight software; and (2) the Ground Operations estimate was also increased by $2.0 million to better balance the spacecraft design schedule with the design effort devoted to mission operations software.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding requirements will provide for fabrication and test of the Galileo science instruments, the probe and the orbiter spacecraft. Significant milestones include the Orbiter Systems critical design review in the first quarter of FY 1980 and the project capabilities review in the fourth quarter of FY 1980. Integration and testing will occur in FY 1981.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Voyager basic mission.............................. ..	16,025	14,400	15,175	19,000
Pioneer Venus basic and extended mission.............	1,100	10,500	10,500	9,800
Pioneer 6-11 extended mission..........	2,106	3,900	3,125	4,000
Helios extended mission..........	700	200	200	---
Viking extended mission....	20,000	5,000	5,000	---
Planetary flight support...........................	24,428	25,300	25,300	26,200
Total....................................	64,359	59,300	59,300	59,000

OBJECTIVES AND STATUS:

The Mission Operations and Data Analysis Program funds the operations phase of planetary missions after development, launch, and initial inflight checkout are complete. It also provides for multimission flight support. Currently active planetary missions being supported within mission operations are Voyager, Pioneer Venus, Pioneer 6-11, Helios and Viking.

The objective of the Voyager mission to the outer planets is to conduct scientific studies of the Jupiter and Saturn planetary systems, including their numerous satellites and the rings of Saturn. If conditions are favorable, one of the two Voyager spacecraft may also go on to Uranus to investigate this exciting planet. While the two spacecraft are cruising to the outer planets, they will also be performing new investigations of the interplanetary medium. Since their launches in the summer of 1977, the two Voyager spacecraft have been cruising on trajectories to Jupiter. Both spacecraft are in good condition for their encounters with Jupiter and its satellites. The primary radio receiver of Voyager 2 failed during the past year; however, the spacecraft is being operated successfully using its backup receiver, even though that equipment is somewhat impaired by a component failure. Encounter operations for Voyager 1 will begin the first week of January 1979. Closest approach to Jupiter will occur on March 5, 1979, followed in a few hours by close encounters with the satellites Io, Europa, Ganymede, and Callisto. Similar operations for Voyager 2 will commence in April 1979, with closest approach at Jupiter on July 9, 1979. A wealth of new planetary data is expected from the investigations provided by the Voyagers as they traverse the immense Jovian system. After their encounters at Jupiter, the two spacecraft will be accelerated on trajectories to Saturn, arriving there in November 1980 and August 1981.

The objectives for Pioneer Venus are to obtain detailed information on the Venusian atmosphere and to investigate the planet's environment. The mission is carried out by two spacecraft: an orbiter launched in May 1978 and a multiprobe launched in August 1978. The orbiter arrived at Venus on December 4, 1978, and was put into a highly elliptic orbit that approaches within 150 kilometers of the surface. On December 9, 1978, the four probes and multiprobe bus entered the atmosphere. The probes made measurements as they descended to the surface at widely separated points, and the bus also collected data. One of the key objectives is to learn why Venus, so Earth-like in many respects, has an atmosphere so different. The mission has been, and continues to be, an outstanding success.

The objective of Pioneer 6-9 is to explore interplanetary space at radial distances from the Sun varying from 0.75 to 1.1 AU. (The Earth's distance from the Sun is 1 AU, an astronomical unit). The objectives of Pioneer 10 and 11 are to explore space beyond one AU, the Asteroid Belt and the environment of Jupiter. Pioneers 6-9, with launches starting back in 1965, are still operational, but are now generally tracked only when unusual solar activities or special alignment with other spacecraft occur. Pioneer 10, launched in 1972, reached Jupiter in December 1973, and the gravity of the massive planet provided the extra impetus to take Pioneer 10 out of the solar system. Pioneer 11, launched in 1973, passed Jupiter in December 1974 and the spacecraft trajectory was influenced by the planet's gravity field in such a way that it will fly by Saturn in 1979. Both spacecraft have returned excellent data and continue successful operation.

Planetary Flight Support provides for mission control and other activities which support the tracking, telemetry and command functions for all planetary spacecraft. The activities include general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL), and selected project functions such as preparation of data records, computer analysis time, and provision for the mission support areas. These functions are performed at the Mission Control and Computing Center at JPL.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Voyager funding requirements in FY 1979 increased by $775 thousand from last year's budget estimate. The additional funds were necessary to provide for increased mission operations staffing to respond to spacecraft anomalies and operational complexities. The increase reflects an offset by a reduction in the amount to support Pioneer 6-11 cruise operations.

BASIS OF FY 1980 ESTIMATE:

The Voyager FY 1980 funding requirements will provide for mission operations during the cruise period between the Jupiter and Saturn encounters. The project scientists will be engaged in analyzing and publishing the results from the two Jupiter encounters in 1979. The flight team will be operating the two spacecraft while each Voyager continues its interplanetary observations. The flight team will also be developing the sequences and software for the Saturn encounters, which will occur in November 1980 and August 1981. Voyager 1's encounter period at Saturn will start with concentrated observations of the ringed planet and its many satellites in late August 1980.

The Pioneer Venus basic mission funds for FY 1980 will support processing and analysis of the data obtained during the multiprobe entry and during the first 243 days of orbital operations. Funds for the extended mission will support continued orbiter operations beyond this period.

For Pioneer 6-11, FY 1980 funds will provide for mission operation and data analysis with emphasis on data from the Saturn encounter of Pioneer 11.

Planetary Flight Support funds for FY 1980 will provide mission control and computing support for all active planetary spacecraft.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Supporting research and technology....................	37,899	34,200	29,500	33,300	5-10
Advanced programs......	6,092	5,400	5,400	5,800	5-11
Mars data analysis..................................	---	4,500	4,500	6,000	5-11
Solar electric propulsion/comet studies..	---	5,000	5,000	---	---
Total..	43,991	49,100	44,400	45,100	

OBJECTIVES AND STATUS:

The Research and Analysis program contains the supporting programs required to assure that data and samples returned from flight missions are fully exploited, to undertake complementary laboratory and theoretical efforts, and to define the science rationale and develop required technology to undertake future planetary missions. The individual programs within the Research and Analysis effort have been restructured to integrate similar functions. Beginning in FY 1980, funding for Solar Electric Propulsion studies and evaluation is included in the Space Flight Flight Operations program, under the cognizance of the Office of Space Transportation Systems.

Supporting Research and Technology -- The Planetary Astronomy activity includes all planetary observations made by ground-based, airborne and Earth-orbital telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio, and the rate of new discoveries continues to be high. The data acquired are used both for basic research in support of planetary program objectives and for direct support of specific flight missions. In the Spring of 1979, the new Infrared Telescope facility in Hawaii will commence planetary observations including support of the Voyager encounters of Jupiter and Saturn.

The Planetary Atmospheres activity includes data analysis, laboratory and theory efforts and flight instrument definition. The properties of other planetary atmospheres are amenable to measurement and can aid us in better understanding of our own weather and climate. This activity has an excellent record of science contributions. Pioneer Venus and Voyager are examples of missions that are returning valuable data that will significantly contribute to this research area and will provide an improved understanding of planetary atmospheres in general.

The Planetary Geochemistry and Geophysics activity is broad in scope and includes studies of the composition and structure of all the classes of solar system objects, the synthesis of data from all sources that relate to the origin and evolution of the solar system, and the definition of instruments for future flight missions. The program supports the synthesis of planetary data already obtained, and the assembly of information needed to prepare for future missions.

To date, the Planetary Geology activity has focused on studies of the inner planets (including the Moon). Shortly, Voyager data pertaining to the Galilean satellites of Jupiter will provide a new dimension for this effort. The geology program is a broadly based effort in which comparative studies of common processes affecting all the inner planets provide a powerful technique for unravelling individual planetary histories, including their early states. Imaging data, both from spacecraft and from ground-based radar, provide the basis for much of the data analysis.

The Planetary Materials activity supports an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties, and other characteristics of returned lunar samples and of meteorites that fall to Earth. These studies continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. At the request of Congress, NASA and the National Science Foundation have analyzed the lunar sample program and have concluded that the National Science Foundation should recognize the growing importance of planetary science and increase its support for high quality research in the area of Earth and planetary science, while NASA should maintain a balanced program of work on extraterrestrial materials consistent with its mission. The FY 1980 lunar sample analysis effort included in the Planetary Materials Program reflects this conclusion of the joint study.

Advanced Programs -- The Advanced Programs activity combines the work of Advanced Studies and Advanced Technical Development, which have been budgeted in previous years as separate items. This year, because of the complementary and interactive nature of these efforts, they have been combined into a single item. The objective of Advanced Programs is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is assessed through interaction with the scientific community. For near-term missions, detailed project planning and technology readiness studies are carried out so that these missions may be undertaken on schedule and within fiscal constraints.

Current studies and supporting activities cover such possible future missions as the Venus Orbiting Imaging Radar (VOIR), a comet mission, a Saturn orbiter mission with Saturn and Titan probes, and an asteroid multiple rendezvous mission.

Mars Data Analysis -- The Mars Data Analysis activity continues in FY 1980 to assure that we fully capitalize on the wealth of data provided by Viking. The activity covers the broad scope of the returned data--biology, chemistry, geology, meteorology, etc. The quality of the first proposals submitted was excellent. FY 1980 funding continues this effort.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The reduction of $4,700,000 in the FY 1979 Supporting Research and Technology Program is a result of Congressional action in reducing the FY 1979 appropriations and requesting NASA and the National Science Foundation to review the lunar sample analysis program.

BASIS OF FY 1980 ESTIMATE:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Supporting Research and Technology....................	37,899	34,200	29,500	33,300

During FY 1980, research efforts will continue in the areas of Planetary Astronomy, Planetary Atmospheres, Planetary Geochemistry and Geophysics, Planetary Geology, and Planetary Materials. Infrared telescopic observations of Jupiter and Saturn will be undertaken in support of the Voyager missions, and radar telescopes will be used to continue the investigation of Venus and other solar system bodies. Other significant observations will be conducted both to increase our knowledge of the outer planets and the small bodies of the solar system and to advance our readiness for future missions. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep atmospheres and in tenuous cometary atmospheres, modeling of global circulation patterns, and the definition of instruments for future missions. Instrument definition is of similar importance in the geochemistry-geophysics area where research efforts will be made to continue to better understand the present state and evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces and will also include a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and cosmic particles will continue in order to determine their chemical and physical properties and thereby to derive their origin and evolutionary history.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Programs	6,092	5,400	5,400	5,800

In FY 1980, the major effort in Advanced Programs will be devoted to continued preparations for the Venus Orbiting Imaging Radar Mission, including more detailed mission definition studies and advanced technology development. Work on the Mars study efforts will continue to provide more detailed mission and system concepts for possible future Mars missions, building on the Viking achievements. Other studies will include continuation of mission definition for a Saturn orbiter with probes into Saturn and its moon Titan, comet mission definition and science selection, and further studies of an asteroid multiple rendezvous mission.

Mars Data Analysis.	---	4,500	4,500	6,000

The Mars Data Analysis activity began in FY 1979 and over 80 research efforts have been initiated in a wide range of discipline areas such as biology, chemistry, geology, and meteorology. The FY 1980 funds will provide for the continuation and/or completion of these efforts and the initiation of a relatively few additional new analyses.

LIFE
SCIENCES

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Life sciences flight experiments....................	9,000	12,400	11,900	12,900	6-3
Vestibular function research.	1,500	3,800	3,800	3,700	6-4
Research and analysis............................	22,800	24,400	24,400	27,300	6-5
Total..	33.300	40.600	40.100	43,900	
Distribution of Program Amount by Installation:					
Johnson Space Center......	13,024	15,425	16,200	16,650	
Kennedy Space Center........	92	300	400	650	
National Space Technology Laboratories.......	50	50	---		
Jet Propulsion Laboratory...	1,578	1,310	1,710	2,050	
Ames Research Center.........	12,552	17,867	16,117	18,480	
Dryden Flight Research Center...	140	100	185	200	
Lewis Research Center.....	56	---	---	---	
Headquarters....................................	5,808	5,548	5,488	5,870	
Total.	33,300	40.600	40,100	43.900	

OFFICE OF SPACE SCIENCE | LIFE SCIENCES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Life Sciences program is to conduct research on the origin and nature of life where access to space has provided us with a new opportunity. This will help us to discover and mitigate the effects of the space environment on humans to facilitate their safe, useful participation in space activities. The realization of this goal, which is intimately linked to our understanding of the basic mechanisms of biological and medical processes, is achieved through a program of research conducted both on Earth and in space. A continuum flows from the ground-based research activities to the flight experiments, and then from flight findings to laboratory work on the Earth. The Life Sciences program is a composite of disciplines addressing all space-related problems in biology and medicine.

The Life Sciences program is composed of two major program thrusts. The first is a program consisting of flight and ground-based experiments, whereby the physiological effects of the space environment on humans are explored. The unique properties of space (e.g., zero-gravity) provide, for the first time in our history, an opportunity to explore significant problems in biology under a set of conditions that cannot be created here on Earth. The second thrust is our studies in planetary biology, with special emphasis on a problem of profound philosophical and scientific significance: the origins and distribution of life in the universe.

Spacelab-1 will be available for inflight research activities in 1981. In preparation for the early flights, and subsequent selection of Shuttle passengers, ground-based research is being conducted presently on the limits of physiological tolerance to space flight stresses. Seven life sciences experiments are being developed by NASA for the Spacelab-1 mission. These experiments emphasize the exploration of the effects of space flight on humans, such as changes in vestibular function and hematological indices and effects of space radiation, and some relate to basic biological sciences, such as the effect of gravity on plant growth and biological rhythms.

The first Spacelab flight dedicated entirely to Life Sciences is planned for 1982. Experiment proposals in response to our Announcement of Opportunity for future Life Sciences Shuttle/Spacelab payloads flights were received in 1978 and are currently being reviewed. Selections for the first dedicated flight will be made in 1979. Development of general purpose equipment for use on these life sciences flights is in progress.

A significant highlight of the Life Sciences program is NASA's ongoing participation in the joint US/USSR Biological Satellite program which will include a Cosmos launch in August/September 1979. Thirteen US experiments will be flown on this flight; these experiments will explore relevant medical and biological problems. In addition, advance planning has been initiated for future US participation in a 1981 USSR biological satellite mission. In conjunction with the flight experiments outlined above, relevant ground-based research continues to provide an adequate data base and rationale for future flight experiments.

Planetary biology is the second major program thrust. The goal is to understand the origins and distribution of life throughout the universe. Particular emphasis is placed on discovering the relationships which link the formation of the solar system to the beginnings of life. The impact of the presence or absence of life on the subsequent evolution of a planet is just beginning to be realized.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

LIFE SCIENCES FLIGHT EXPERIMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Life sciences flight experiments	9,000	12,400	11,900	12,900
Space transportation system operations	(---)	(---)	(---)	(2,800)

OBJECTIVES AND STATUS:

The objective of the Life Sciences Flight Experiments program is to expand our understanding of certain basic biological and medical processes. This knowledge will improve human ability to function appropriately in the space environment. The program includes the whole process of planning, experiment development, inflight operations and data analysis. The experiments flown will deal with the effects of weightlessness, and other unique space environmental conditions, on living systems.

Proposals have been received in response to our Announcement of Opportunity. The initial selection of flight experiments for the first flight will be made in mid-1979. The proposals encompass a wide range of science endeavors in the disciplines of biology, medicine, behavioral performance, and technology.

The plan is to provide general-purpose flight hardware required for the flight experiments, thus eliminating unnecessary duplication of equipment.

CHANGE FROM FY 1979 BUDGET ESTIMATE:

The decrease of $500 thousand in the FY 1979 estimate is the result of the Congress' general reduction in NASA's FY 1979 R&D appropriation request, and is consistent with a delay in the early Shuttle/Spacelab flights.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the selected flight instruments will be in design. The general equipment necessary to support the flight experiments will continue to be developed, and the development of ground support equipment for payload test and integration will proceed.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

VESTIBULAR FUNCTION RESEARCH

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Vestibular Function Research	1,500	3,800	3,800	3,700

OBJECTIVES AND STATUS:

Preliminary results from U.S. as well as USSR manned flight missions have indicated that a number of flight personnel experienced "motion-sickness" during flight. In varying degrees, performance was compromised during the illness. It is fairly well accepted that the neurophysiology associated with the vestibular organ is responsible for the illness.

The Vestibular Function Research (VFR) project provides for development of a reusable flight facility to conduct investigations on the otolith and the neurosensory response meachnisms associated with motion in a zero-gravity environment. The response to the Life Sciences Announcement of Opportunity reflects a need by the vestibular research community for an opportunity to conduct investigations in a unique VFR facility. The responses also indicate a need for reconsideration of our approach to implementation of this facility. Accordingly, the program will continue definition and design activities in FY 1979 and will start development in FY 1980.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, selected investigators will develop the flight experiment protocols, and initiate specific ground testing to generate biological records for baseline ground data. Instrumentation methods will be examined and evaluated. A prototype of the flight hardware, including both tilt and centrifuge subsystems, will undergo design, fabrication and qualification tests.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Life sciences supporting research and technology	18,000	20,400	20,400	23,000
Planetary biology and protection	4,800	4,000	4,000	4,300
Total	22,800	24.400	24.400	27.300

OBJECTIVES AND STATUS:

The Research and Analysis activities of the Life Sciences program support the ground-based research in space-related biological and biomedical problem areas that have been identified in previous flights or have been determined to be highly probable in future flights.

The Life Sciences Supporting Research and Technology program is comprised essentially of three elements: (1) biomedical research, (2) space biology, and (3) life support systems. The primary function of biomedical research is to improve our understanding of physiological and behavorial effects of spaceflight and the attendant hazards to humans, for the purpose of enhancing his capabilities and safety in space. The program is designed to elucidate the mechanisms of adverse physiological effects of the space environment, and to identify techniques and devices for the prevention and correction of these effects. Specific operational requirements such as medical selection and retention criteria, together with environmental protection requirements, are continuously reevaluated and updated. There is a continuum of basic and applied research which ranges broadly from cardiovascular, vestibular, skeletal and other physiological areas to clinical medicine and special hazards such as radiation.

The space biology activity investigates the role of gravity on biological processes so as to develop hypotheses of how gravity may have influenced the functions and shapes of the various life forms. The program provides basic ground-based information necessary both for optimizing the selection of flight experiments, and for designing future life support systems.

The life support systems activity concentrates on finding cost-effective alternatives to presently utilized open-loop life support systems by the development and demonstration of physio-chemical and biological regenerative systems. These systems will minimize the requirement for expendables and supplies on flights of long duration. The goal of this effort is to provide the basis for the eventual support of humans in space for a long duration.

The thrust of the planetary biology research activity is to understand the origins and distribution of life, or precursor molecules of life, throughout the universe. In particular, such efforts hope to provide an understanding of the evolutionary pathways that led to the emergence of life from primordial molecules presumed to be present after the formation of this planet. Furthermore, data from analysis of the Mars soil and from extreme environments on earth (e.g., the Antarctica and Precambrian rocks) has provided new awareness for future research.

The planetary protection program provides updated methodologies for the control of biological and particulate contamination of all outbound spacecraft. In addition, methodologies and strategy for sample return missions are being evaluated.

BASIS OF FY 1980 ESTIMATE:

The biomedical research will continue to investigate the basic mechanisms, potential risks, and acceptable countermeasures associated with sustaining humans in space, emphasizing ground-based investigations.

The space biology program will expand to provide adequate ground-based support data for the anticipated increased number of flight experiments in the Shuttle/Spacelab program. Emphasis will be placed on identifying relationships between stress on biological processes and gravity.

The research in advanced life support systems will expand to include preliminary studies to investigate basic biological processes and physical-chemical methods which could provide the capability to recycle waste, food, atmosphere, and water.

The planetary biology program will emphasize research in chemical evolution and the origin of life. Analysis of the data from the Martian soil has provided us with significant insights regarding the distribution of carbon molecules in the solar system, and has suggested novel avenues for future research.

SPACE AND TERRESTRIAL APPLICATIONS PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE AND TERRESTRIAL APPLICATIONS

	Budget Plan			
		1979		1980
Programs	1978 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Space applications	234,800	274,300	274,800	332,300
Technology utilization	9,100	9,100	9,100	12,100
Total	243,900	283,400	283,900	344,400

SPACE
APPLICATIONS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — SPACE APPLICATIONS PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Resource observations	102,845	136,650	139,150	141,400	7-7
Environmental observations	75,415	67,600	67,900	117,200	7-20
Applications systems	13,340	18,200	15,700	24,200	7-38
Technology transfer	10,400	10,950	10,950	10,300	7-43
Materials processing in space	13,650	20,400	20,400	19,800	7-45
Space communications	19,150	20,500	20,700	19,400	7-50
Total	234,800	274,300	274,800	332,300	

Distribution of Program Amount by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Johnson Space Center	27,206	21,875	24,347	31,150
Kennedy Space Center	535	500	703	825
Marshall Space Flight Center	16,679	32,550	27,506	29,525
National Space Technology Laboratories	3,890	3,450	2,955	3,750
Goddard Space Flight Center	126,683	160,470	156,398	184,100
Jet Propulsion Laboratory	28,593	18,545	22,612	22,300
Wallops Flight Center	3,533	2,610	2,952	4,125
Ames Research Center	6,191	6,000	6,285	10,550
Langley Research Center	9,035	16,600	12,134	19,125
Lewis Research Center	3,030	2,850	3,735	5,125
Headquarters	9,425	8,850	15,173	21,725
Total	234,800	274,300	274,800	332,300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Resource Observations:		
Earth Resources Technology Satellites	Launch of LANDSAT-D	1981
Magnetic Field Satellite	Launch of MAGSAT	1979
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1980
	Spacelab Payloads	Beginning in 1981
Environmental Observations:		
Stratospheric Aerosol and Gas Experiment	Launch of SAGE	1979
Global Atmospheric Research Program	First GARP Global Experiment	1978-1979
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1980
	Spacelab Payloads	Beginning in 1981
Earth Radiation Budget Experiment	Launch of ERBS-A	1983
	ERB instrument to be launched on NOAA F&G	1982-1984
Halogen Occultation Experiment	HALOE instrument to be launched on Spacelab mission and ERBS-A	1982-1983
Materials Processing in Space:		
Sounding Rocket Missions	Launch about 2 annually	1979-1980
	Flight of Materials Experiment Assembly	Beginning in 1980
Shuttle/Spacelab Payload Development	Spacelab Payloads	Beginning in 1982
Space Communications:		
Search and Rescue Mission	Instruments to be launched on NOAA (TIROS-N series) spacecraft	1982-1984
Shuttle/Spacelab Payload Development	Flight of Adaptive Multibeam Antenna	1982

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Reimbursable Missions:		
GOES*	Launch of GOES D through F	1980-1983 (Subject to call-up by NOAA)
NOAA*	Launch of NOAA A-G	1979-1984 (Subject to call-up by NOAA)

*National Oceanic and Atmospheric Administration (NOAA) funded.

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Space Applications program is to conduct research and development activities that demonstrate and transfer space-related technology, systems and other capabilities which can be effectively used for down-to-Earth practical benefits. These activities are grouped in the following general areas: Resource Observations, Environmental Observations, Applications Systems, Technology Transfer, Materials Processing in Space, and Space Communications.

In each of these areas, programs are being conducted and planned to contribute to the solution of pressing national, as well as international, problems and needs.

Resource Observations -- This program addresses needs for information of vital economic value to the U.S. and of importance to global humanitarian concerns such as the world's food and energy supplies. The principal objectives are to develop the use of space and space technology to provide the Nation with a global capability for the monitoring and management of essential agricultural commodities, for water resources management, for mineral and petroleum exploration, for land use assessment and for the eventual forecasting of crustal hazards. Inherent in these objectives is the involvement of the users of space-derived information in the development, test, verification and application of these techniques.

Principal activities include the identification of user information needs, the understanding and development of remote sensing techniques, provision for the routine acquisition of space data, experimental projects with users, and the eventual evolution to routine global data collection systems. Currently Landsats-2 and -3 are providing a wide variety of useful data. Landsat-D, with improved capabilities, is under development and will be launched in 1981. Other experiments intended to test the applicability of microwave measurements and stereoscopic imaging for geological studies are planned for flight on the early Shuttle missions. Studies are also underway to evaluate the use of space systems for global stereoscopic imagery for resource exploration. Joint research activities with other Federal agencies are planned to advance our knowledge of how to apply multiple data sources in improving agricultural early warning and crop commodity forecasting and in advancing the scientific understanding of the solid Earth.

Environmental Observations -- Understanding the dynamics and limitations of our environment is essential to our long-term survival. NASA's Environmental Observations Program aims at improving the understanding of processes in the atmosphere and oceans, providing space observations of parameters involved in these processes and extending the capabilities to predict environmental phenomena and their interaction with human activities. The interactions among these processes and the interrelationship of the atmosphere, ocean, land and space environments can only be fully studied on a global basis from space. Capitalizing on this global perspective, the program objectives are to study tropospheric and stratospheric pollution, to measure the radiative budget of our planet, to improve numerical weather prediction, and to develop remote sensing of ocean surface properties. NASA's program includes research efforts plus the development, demonstration and transfer of new technology for global and synoptic measurements. Research satellites give a special view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

With the transfer of organizational responsibility for the Upper Atmospheric Research Program from the Office of Space Science, the Environmental Observations Program now includes studies of all of the layers of the atmosphere from the turbopause (100-110 km) down to and including the upper layers of the oceans. The program areas now include: (1) Upper Atmospheric Research, (2) Global Weather, (3) Severe Storms, (4) Climate, (5) Environmental Quality (including Stratospheric Pollution and Tropospheric Pollution), and (6) Oceanic Processes (including Water Pollution, Ocean Dynamics, Ice Dynamics, and Coastal Processes). This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography, and focuses on the special contributions of space-derived data. In support of these programs, four spacecraft were launched in 1978: SEASAT, TIROS-N, GOES-3 and NIMBUS-7. The Stratospheric Aerosol and Gas Experiment will be launched in 1979. Work is continuing on design and development of the Earth Radiation Budget Experiment, the Halogen Occultation Experiment, and Shuttle/Spacelab payloads, such as the Atmospheric Cloud Physics Laboratory.

Applications Systems -- This program supports Space Applications requirements for use of airborne facilities, definition of data management technology requirements, and payload mission design and integration. Program responsibilities also include definition and coordination of payload requirements, assessment of Space Transportation System accommodation requirements and payload integration and operations analysis.

Technology Transfer -- In recent years, remote sensing technology has matured significantly and is now increasingly able to provide much of the resource and environmental information needed to meet Federal and other legislative requirements, to aid in the search for new resources, and to meet other commercial demands for synoptic information such as agricultural production forecasting. The objectives of the Remote Sensing Technology Transfer Program are to provide for the validation, transfer and widespread dissemination of proven technology applications to operational use, maximizing the benefit to the Nation from NASA technology. Because operational jurisdiction for use of this technology rests elsewhere, the program assists in the establishment of self-sustaining user capabilities for the application of space technology outside of NASA in public and private sectors and provides a communication channel through which user needs can be assessed and factored into future NASA program planning.

Materials Processing in Space -- The Materials Processing in Space program emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Its goal is to test and demonstrate the capabilities of the space environment for materials processing and provide opportunities for independently funded users to exploit space flight for processing activities related to their own needs. The program's ground-based research will be enhanced in accordance with recent recommendations from the National Academy of Sciences to broaden the scientific basis for future efforts. New activities will be initiated in response to proposals from the scientific community, while ongoing effort will emphasize work on focused problems that are important for both science and technology. The Space Processing Applications Rocket (SPAR) project will conclude its flight operations with expendable sounding rockets and prepare for continuing STS experimentation, using self-contained packages of rocket payload equipment mounted in the Shuttle payload bay by means of the Materials Experiment Assembly. Design work on the program's initial group of STS payload equipment will be completed in FY 1980, leading to fabrication in FY 1981 and flight on STS missions in 1982. This equipment will be used to perform experiments to demonstrate the utility of space flight for materials research and to prepare a scientific data base for applications that will be developed in later years.

Space Communications -- American private enterprise built a new industry upon NASA's early pioneering work in satellite communications. Industry now offers strong support for a renewed NASA effort in satellite communications R&D in order to assure a large U.S. participation in this segment of a rapidly growing worldwide telecommunications market. In FY 1980, NASA will begin focusing on the development of technology to increase the usable capacity of the radio frequency spectrum and geosynchronous orbit. In particular, NASA will be working toward the development of multi-beam antennas and on-board switching techniques. In FY 1980, user experiments and demonstrations on NASA's ATS-1 and ATS-3 experimental satellites will continue. By the end of FY 1979, public service user experiments on ATS-6 and CTS will have been completed, and FY 1980 will be the first of two phase-out years for those two satellites. A significant effort is being undertaken to provide technical consultation and support to U.S. Government agencies, including NASA, participating in the 1979 World Administrative Radio Conference (WARC)--the first of its kind since 1959.

Work is continuing on the development of an experimental Search and Rescue Mission. This system will employ sensitive receivers and high gain antennas, carried on spacecraft, to demonstrate the feasibility of obtaining a significant increase in the capability to detect and locate distress signals from general aviation aircraft and certain marine vessels. This interagency program is being conducted jointly with Canada and France; discussions with the Soviet Union are also underway. The launch of the first operational meteorological satellite equipped with the search and rescue instrumentation is planned for 1982.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESOURCE OBSERVATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
LANDSAT-3	3,155	700	700	---	
LANDSAT-D	48,200	97,500	97,500	89,800	7-9
Heat capacity mapping mission	600	300	300	---	
Magnetic field satellite	10,500	3,900	3,900	1,600	7-11
Shuttle/Spacelab payload development	3,620	6,000	6,000	1,600	7-12
Extended mission operations	200	---	350	1,500	7-13
Geodynamics	6,940	8,600	8,200	13,100	7-14
Applied research and data analysis	29,630	19,650	22,200	33,800	7-16
Total	102,845	136,650	139,150	141,400	

OBJECTIVES AND STATUS:

The goal of the Resources Observations Program is to develop and demonstrate the application of space observations and space techniques to the acquisition of important information regarding the Earth's agricultural, water, land, mineral, and energy resources, and to acquire new scientific information on the Earth's dynamic characteristics to allow a physical description of the planet. To achieve this goal, the program is focused towards: (1) the development of basic techniques for sensing the characteristics of the Earth's surface and extracting useful information from the remotely sensed data from space; (2) the development of precise measurements of the movements of the Earth's crust and its other dynamic characteristics to support research in earthquake mechanisms; (3) the conduct of joint research and development programs with elements of the Federal, public and private sectors that have major responsibilities and information needs in managing resources or are interested in the use of space-derived data to augment other information sources; (4) the provision of remotely sensed data from space on a continuing basis to a variety of users; and (5) the evolutionary development of the global space sensing capability for the routine dissemination of timely and comprehensive resource information.

Principal elements of the program include the development of space and supporting ground systems; improved data processing and analysis techniques; Shuttle and aircraft support for sensors and technique development; and basic and focused research for monitoring, analyzing, and modeling the vegetated and structural features of the Earth.

LANDSAT-2 and LANDSAT-3, which was launched in March 1978, are operating and providing data routinely. LANDSAT-D is being developed and is on schedule for launch in 1981. In addition to continuing the availability of Multispectral Scanner (MSS) data, LANDSAT-D will provide imagery with the improved spectral and spatial resolution needed to expand the use of space data for agricultural, water resource and other applications,

Information on the Earth's geologic structure, chemical composition, and crustal processes is needed to improve the effectiveness of the exploration for new mineral and energy deposits. LANDSAT imagery has been very useful for this purpose, but is limited by its orbit and sensor characteristics. Therefore, several new information sources and techniques are being evaluated to assess their applicability for aiding in resource exploration. The Heat Capacity Mapping Mission was launched in 1978. Information from this mission is being used to discriminate rock types and soil compositions based on the thermal inertial characteristics of the material. In late 1979, the Magnetic Field Satellite (Magsat) will be launched to provide an up-to-date survey of the Earth's global magnetic field. These data are needed to produce magnetic field charts and maps for public use. In addition, the Magsat data will be used for studies of crustal inhomogeneities. Several experimental instruments are being developed to test the use of optical and microwave techniques for acquisition of geologic information. An imaging radar optimized to enhance the discrimination of terrain features and a microwave radiometer to differentiate among rock types and to determine surface composition are planned to fly on an early Shuttle mission. A Large Format Camera for precision mapping of large geographic areas and for studies of the use of stereographic imagery is planned for flight in 1980.

A major aspect of the Resource Observations Program is research associated with understanding and extracting the physical relationship of emitted and reflected radiation with vegetated and other surface features from remotely sensed data; with the development of models appropriate to the management of resources; and the evaluation of the use of space-derived data along with other data sources in meeting user needs. The scope of these activities ranges from individual scientific studies to projects such as the Large Area Crop Inventory Experiment (LACIE). Based on the results of the research, Application Pilot Tests are used to test and expand the research concepts in the realism of the users' environment. The LACIE, a cooperative effort with the U.S. Department of Agriculture (USDA), was completed in 1978. LACIE demonstrated the usefulness of space data in forecasting wheat production in the U.S. and abroad; it also identified areas where further research is needed. In FY 1980, a joint Agriculture Research Program will be initiated with the U.S. Department of Agriculture, the Department of Commerce (National Oceanic and Atmospheric Administration), Department of the Interior, and Agency for International Development to address priority information needs identified by the USDA. This will include a select group of crops and producing countries of significance to world trade and world nutrition. In FY 1980, three Application Pilot Tests will be completed: A wildland vegetation inventory'with the Bureau of Land Management; a forest resource information system with the St. Regis Paper Company; and a land use and change detection effort with the U.S. Geological Survey. Other Application Pilot Tests will continue: *An* urban area boundary delineation project with the Bureau of the Census; an irrigated lands assessment for water management project with the State of California's Department of Water Resources, and a cotton crop inventory system project with Cotton, Incorporated. Two new pilot tests will be selected for initiation in FY 1980. Candidates include a land productivity assessment with the Agency for International Development and a channel contour mapping test with the U.S. Army Corps of Engineers. In FY 1979, at the request of the Congress, studies were initiated to define the requirements for stereoscopic data for resource exploration and to develop technical and implementation approaches, as well as cost estimates. These system definitions for a future Stereosat mission will be completed in FY 1980.

The Geodynamics Program applies space observational techniques to studies of the solid Earth. These studies are expected to contribute to better understanding of the physical character and dynamic motions of the Earth and to mechanisms associated with catastrophic crustal movements. Major activities conducted under the Geodynamics Program include the development of improved models of the Earth's gravity field, and the development of techniques for the detection and measurement of tectonic plate motion and crustal deformation.

While the techniques and approaches used in these studies are unique, the questions addressed are fundamental problems in geophysics and geodesy. The solution to these problems is becoming more and more important because of population increases in seismically active areas of the United States and other parts of the world. In FY 1980, a joint program will be initiated with the U.S. Geological Survey, the National Science Foundation, the National Geodetic Survey, the Department of Defense and with other countries to begin to monitor the motion and internal stability of several major tectonic plates and to determine the crustal deformation in seismically active areas.

Earth Resources Technoloev Satellite (LANDSAT-D)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft (multimission modular spacecraft)	15,000	20,000	20,000	6,000
Spacecraft systems and sensors	31,500	60,300	56,200	62,800
Ground data processing system	1,700	17,200	21,300	21,000
Total	48,200	97,500	97,500	89,800
Delta (expendable launch vehicles program)	(6,600)	(10,000)	(10,000)	(---)

OBJECTIVES AND STATUS:

The objective of the LANDSAT-D project is to continue the exploration of advanced research and development techniques for satellite-based Earth resources remote sensing systems with the experimental Thematic Mapper and the flight-proven Multispectral Scanner. The initial LANDSAT-D launch is planned for late 1981; the backup spacecraft will be available for launch six months after the initial launch. The major technical focus of the LANDSAT-D project involves a test of both the Thematic Mapper instrument's capabilities and an improved ground data handling system. The Thematic Mapper--on which development was initiated in FY 1977--will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of LANDSAT data and to enhance many current uses.

The Multispectral Scanner (MSS) contract was awarded in March 1978. The design changes for the MSS which are required for the LANDSAT-D mission will be verified by tests during FY 1979 and the protoflight model fabrication will continue to support an early FY 1981 delivery to the mission contractor. A second MSS for the backup spacecraft has been added to the project to ensure that the initial and backup spacecraft have identical configurations. Development of the Thematic Mapper is on schedule for delivery to the mission contractor in October 1980. Design of the instrument is complete and integration of the engineering model is in progress. Systems testing of the engineering model is being initiated in FY 1979 and will be completed early in FY 1980.

Work is continuing on schedule for delivery of the systems modules of the Multimission Modular Spacecraft (MMS) to the MMS integration contractor in late FY 1979. The MMS integration contractor was selected during 1978. The LANDSAT-D mission contractor, responsible for development of mission-unique space hardware and the ground segment, was selected in late FY 1978. The contract also provides for the integration of the payload and the MMS. During FY 1979 design of the mission-unique items will be completed and fabrication initiated.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current FY 1979 funding requirements for LANDSAT-D remain the same as the budget estimate. Adjustments between the project elements were based on detailed scheduling requirements.

BASIS OF FY 1980 ESTIMATE:

The Thematic Mapper engineering model testing will be completed and it will be delivered during early FY 1980. In addition, the fabrication and testing of the protoflight model will be completed and it will be delivered to the mission contractor in late 1980. The flight model fabrication and subassembly testing will also take place during FY 1980. In addition, the major elements of the protoflight Multispectral Scanner, such as the scan mirror assembly, radiometer and multiplexer, will be tested and integrated, and fabrication of the backup MSS for LANDSAT-D will be initiated. The MMS will be integrated and delivered to the LANDSAT-D mission contractor. Integration of the MMS and the LANDSAT-D mission-unique equipment, such as the solar array, tracking and data relay satellite system antenna and communications system, will be initiated. Design, procurement and fabrication of the ground system will be completed during FY 1980 and acceptance testing of the ground system will be initiated.

Magnetic Field Satellite (Magsat)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	8,908	3,220	3,220	460
Experiments	1,427	380	380	840
Ground operations	165	300	300	300
Total	10,500	3,900	3,900	1,600
Scout (expendable launch vehicle program)	(1,100)	(1,400)	(1,400)	(---)

OBJECTIVES AND STATUS:

The Magnetic Field Satellite (Magsat) Mission is designed to measure near-Earth magnetic fields on a global basis. The objectives are to obtain an accurate description of the Earth's magnetic field; to obtain data for use in the update and refinement of world and regional magnetic charts; to compile global crustal magnetic anomaly maps; and to interpret those maps in terms of geologic/geophysical models of the Earth's crust. The United States Geological Survey (USGS) plans to utilize the field models to update regional and global magnetic charts that they will issue in 1980. The USGS also plans to use the field models and the basic magnetometer measurements to derive magnetic anomaly maps for use in its natural resource assessment studies.

The spacecraft will be launched into a low Earth, near polar orbit by the Scout launch vehicle. The basic spacecraft is made up of two distinct parts: the instrument module, which contains a vector and a scalar magnetometer; and the base module which contains the necessary data handling, power, communications, command, and attitude control subsystems to support the instrument module. The base module with its subsystems is comprised primarily of residual Small Astronomy Satellite (SAS-C) hardware. The $plied Physics Laboratory of the Johns Hopkins University is developing the instrument module, with the exception of the magnetometers; building the base module; and serving as the integration and test contractor.

All major subcontract deliveries (i.e., instruments, tape recorders, transponders, star cameras) have been made. Mechanical integration of the base module and instrument module will be completed in January 1979. This will be followed by system tests and calibration. An Announcement of Opportunity was issued in September 1978 for scientific data analysis investigations. Selection of investigations is scheduled for mid-1979. The program is on schedule for a planned launch in late 1979.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funds provide for post-launch support, spacecraft operations, and data analysis. This will include the processing and distribution of data, initial spacecraft orbit and attitude determination, and computation of the field models. Support will also be provided for the precision attitude determinations required to use the vector data for magnetic anomaly studies. The major activity will be the analyses conducted by selected Magsat principal investigators.

Shuttle/Spacelab Payload Development (Resource Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Orbital flight test payload development	2,790	1,600	1,430	600
Large format camera................................	830	4,400	4,570	1,000
Total	3,620	6,000	6,000	1,600

OBJECTIVES AND STATUS:

The Space Transportation System will be used to test, demonstrate, and evaluate earth-viewing remote sensing instruments and systems and to obtain data for resource observations research. The objective of this project is to develop instruments which will fly on Shuttle, orbital flight test missions and to develop a Large Format Camera to fly on Shuttle operational missions. The orbital flight test payload is under development. The instruments include: the Shuttle Imaging Radar (SIR-A) for all-weather identification of terrain features; a Shuttle Multispectral Infrared Radiometer (SMIRR) to conduct research for the optimum spectral bands for geological exploration; and an Ocean Color Scanner to assess the information which can be obtained from improved color sensing techniques in open ocean areas. The SIR-A will be the first use of spaceborne radar specifically for land form analysis. It is an adaption of the single frequency Seasat Synthetic Aperture Radar and will demonstrate the contributions an early radar system can make in resource observations. The Large Format Camera will have direct application to precision mapping of large geographic areas, and its stereo capability will be especially useful to mineral and petroleum resources exploration. A contract for the Large Format Camera development was signed with ITEK in 1978. A Large Format Camera Interagency Working Group was formed to support camera design and orbiter interface reviews; to evaluate pre-mission camera performance; to determine initial mission coverage requirements; to plan the investigations required to determine data utility; and to prepare post-flight data usefulness and system performance reports.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The total estimate for Shuttle/Spacelab payload development activities in FY 1979 remains the same as the FY 1979 budget estimate. The redistribution within the total reflects rephasing of requirements consistent with current flight plans.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, the Resource Observations payload will be integrated into the Shuttle orbiter. The flight will be conducted, and data processing and analysis will be initiated. Development of the Large Format Camera will be completed, and it will be shipped to KSC for integration into the Spacelab pallet.

Extended Mission Operations (Resource Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Heat capacity mapping mission (HCMM)	---	---	200	600
LANDSATS-2 and -3....................................	200	---	150	900
Total......	200	---	350	1,500

OBJECTIVES AND STATUS:

The objective of extended mission operations is to capitalize on the expected continued performance of the LANDSATS-2 and -3 and HCMM satellites beyond the planned mission duration. Data products from these missions are being used to support research activities in agriculture, water resources, geology and land use.

LANDSATS-2 and -3 were launched in January 1975 and March 1978, respectively. Operations for the LANDSAT missions as provided for in the LANDSAT-3 budget extend only to March 1980. LANDSATS-2 and -3 are major sources of space data for domestic and international users and essential elements of planned and continuing experimental demonstration activities.

The HCMM was launched in April 1978 and was planned for one year of operations. The mission provides thermal imagery which is being analyzed to assess the feasibility of using the thermal inertial characteristics of surface material to discriminate rock and soil types and for soil moisture studies.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

In FY 1979, funds were provided from Applied Research and Data Analysis to support continuation of services provided to LANDSAT users and to extend HCMM operations and data analysis support from April 1979 to October 1979.

BASIS OF THE FY 1980 ESTIMATE:

The FY 1980 funds provide for continuation of the LANDSAT-2 and -3 operations from March 1980 to October 1980 and for an additional year of HCMM operations. The LANDSAT data will be processed and provided to the U.S. Geological Survey's EROS Data Center for dissemination. The HCMM funds also provide for data processing and continuation of approved principal investigators' studies.

Geodynamics

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Crustal dynamics project	--	5,400	5,400	10,100
Modeling and technique development	6,940	3,200	2,800	3,000
Total	6,940	8,600	8,200	13,100

OBJECTIVES AND STATUS:

The goal of the Geodynamics Program is to use space technology to gain a more complete understanding of the dynamic processes occurring within and on the surface of the solid Earth. The nature of these processes, in terms of the evolution of the tectonic plates, and the forces that drive and deform the plates are fundamental problems in solid Earth sciences, with important implications for earthquake studies and resource exploration. Studies of geophysical phenomena such as the wandering of the Earth's polar axis and variations in the Earth's rotational rate are important because of suspected causative relationships with weather and climate, with mass motions internal to the Earth, and with mass redistribution within the Earth's upper layers. Mapping and modeling of the global gravity field provide information needed for understanding plate driving mechanisms, crustal processes associated with the formation of mineral and petroleum deposits, and for studies of oceanic circulation and current systems.

The objectives of the Crustal Dynamics project are to detect and monitor global tectonic plate motions to understand how and why the plates are moving; to determine if deformation internal to the plates is related to the unusual occurrence of major earthquakes away from plate boundaries; to map the accumulation of crustal strain in the vicinity of seismically active plate boundaries to understand how and where this energy is stored; and to observe the crustal motion prior to and after major earthquakes to understand how the accumulated energy is released. The results of this project are expected to contribute to the understanding of earthquake mechanisms and hence to the eventual development by other agencies of predictive techniques. The project will be conducted jointly with the USGS, NOAA, NSF, Defense Mapping Agency and, through international arrangements with other countries.

The principal measurement techniques for the crustal dynamics studies are laser ranging to satellites and very long baseline interferometry (VLBI), using signals from radio stars. During the past several years, measurement repeatabilities of ± 4 centimeters have been achieved for continental distances using fixed VLBI and to ± 6 centimeters over 500 kilometer distances using mobile VLBI. Work is continuing on identifying systematic biases in these techniques with the eventual goal of achieving measurement precisions of 1-2 centimeters. In mid-1979, we plan to deploy mobile lasers globally to range to the Laser Geodynamics Satellite (Lageos) for studies of polar motion, Earth rotation, solid Earth tides, and tectonic plate motion and deformation. Three of these lasers are now located at sites in the western U.S. to support continuation of the San Andreas Fault Experiment campaigns which were initiated in 1972. The Lageos data will be analyzed by Principal Investigators selected in response to an Announcement of Opportunity issued in October 1978. An experimental, highly mobile laser system, capable of visiting as many as twenty-five sites per year, is being completed by the University of Texas, Austin, under contract to NASA. The mobility and ranging performance of this Transportable Laser Ranging System (TLRS) will be tested later this year. In FY 1979, joint VLBI observations programs are planned with VLBI facilities in Sweden and West Germany. These experiments will be the first to measure the rate at which the North American and European continents are separating.

Also in FY 1979, NASA is assisting NOAA in converting radio antenna systems in Massachusetts, Florida and Texas to VLBI. These stations will form the basis for a NOAA polar motion and Earth rotation monitoring system which is scheduled to be operational in 1983. The Geodynamics Modeling and Technique Development Program supports studies of solid Earth dynamics, gravity and magnetic field modeling, geoid and magnetic anomaly mapping, and new system concepts. The principal objectives are to develop a better understanding of physical processes associated with crustal deformation mechanisms, polar motion, and Earth rotation, and to develop dynamic Earth models.

Progress with gravity field and geoid modeling has resulted in models which depict structural features such as deep ocean trenches and sea mounts, variations in ocean surface topography, and other gravitational variations associated with crustal densities. For studies of tectonic and crustal processes and oceanic circulation and currents, gravity field models accurate to a few hundred kilometers and several milligal are needed. Improvements to gravity field models are being sought through the use of satellite altimeter data. Studies are also underway to evaluate the need for a gravity field satellite to achieve the better accuracies.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The change in the FY 1979 funding reflects the transfer of topographic and magnetic mapping efforts from Geodynamics to Applied Research and Data Analysis.

BASIS OF FY 1980 ESTIMATE:

Beginning in FY 1980, the crustal dynamics studies will concentrate on the initiation of regional deformation studies in western North America and in the Caribbean, and on the establishment of baselines across active plate boundaries in several areas of the world. Mobile VLBI and laser ranging stations will be used to monitor, annually or semiannually, the vertical and horizontal displacement of points within a network of sites. Cooperative programs will be established with other countries to begin to study plate boundaries which are similar to or different from the San Andreas boundary to help elucidate the processes at the San Andreas boundary. Activities will also be initiated to monitor the motion and stability of the North American, Pacific and Australian plates and to expand the global plate measurement studies through cooperative arrangements with laser and VLBI facilities in other countries. In the modeling and technique development activity, FY 1980 funds will provide for the continuation of gravity field and geoid modeling as well as models of the motion of the solid Earth and of tectonic processes. Work will begin on formulating the basis for the eventual evolution of a global model of the dynamic Earth which will have broad application to basic science and to our understanding of geophysical processes.

Applied Research and Data Analysis (Resource Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Renewable resources................................	16,200	16,100	17,950	23,000
Agriculture research enhancement....................	(---)	(---)	(---)	(3,400)
Non-renewable resources............................	3,045	2,000	2,700	3,600
Applications pilot tests...........................	10,385	1,550	1,550	2,700
Operational Earth resources system (OERS) definition.	---	---	---	3,000
Advanced studies....................................	---	---	---	1,500
Total..	29,630	19,650	22,200	33,800

OBJECTIVES AND STATUS:

The goal of this program is to develop remote sensing capabilities through theoretical studies, ground-based research and flight instrument development that can aid in the management of renewable and non-renewable resources and can monitor the impact of man and his works on the natural environment. Observables include surface characteristics such as type and extent of vegetation; characteristics of exposed soil and rocks; snow and ice cover, water improvements and soil moisture; geological structure and landforms; and the works of man such as urban and suburban developments, major facilities and surface mines. The program is closely coordinated with and in many instances developed in collaboration with other Federal agencies (such as the Department of Agriculture (USDA), Department of the Interior (DOI), Department of Commerce (DOC), Department of Defense (DOD), Federal Power Commission (FPC), and Agency for International Development (AID), state and local governments, and the private sector (e.g., the Geosat Committee)). This program supports the ground-based and the aircraft-based activities for Renewable and Non-Renewable Resource Observations research. The objectives of this effort are as follows: to improve machine-aided interpretation and classification techniques, data handling techniques, and data processing equipment, which are needed to increase efficiency in the transformation of space-derived data into information for utilization by the user community; to test this capability with the users through Applications Pilot Tests; to develop new sensors operating in the visible, infrared, and microwave regions of the spectrum, with emphasis on the latter two; to analyze user requirements for new types of space-acquired data; to develop and demonstrate ground-based or airborne systems that are derived from space technology, processes, management techniques or operations that contribute to the timely solution of natural resources problems. Through FY 1979, emphasis has been placed on developing techniques to interpret and use the visible and infrared data from LANDSATS 1-3, the limited amount of microwave data obtained from Seasat, the thermal data from HCMM, and aircraft data from visible, infrared, and microwave sensors. Studies are underway to develop capabilities to analyze and interpret the data which will be obtained by future systems, such as the seven channel, higher resolution data expected from LANDSAT-D, the multichannel data to be provided by the Shuttle Multispectral Infrared Radiometer (SMIRR), and the optimized look-angle radar data expected from the Spaceborne Imaging Radar (SIR-A).

In Renewable Resources, the major emphasis is on the new thrust in agriculture research. This six-year program is a joint undertaking of the Department of Agriculture, National Oceanographic and Atmospheric Administration, Agency for International Development, Department of the Interior and NASA. Techniques will be developed to use satellite remote sensing data to augment or replace existing sources of information, or to provide information not presently available, in the priority categories established by the Department of Agriculture. (Primary emphasis is placed on the first two items).

1. Early warning: develop meteorological parameters to indicate situations that will cause major changes in quality or production of a commodity. Landsat data will be used in checking and quantifying the event.

2. Commodity production forecasts: develop and test techniques for improving the quality and objectivity of foreign commodity forecasts.

3. Land use classification activities will improve domestic area determination at state and local levels and will develop techniques to monitor land use changes impacting agriculture.

4. Renewable Resource (forestry, range and wildlands): will support USDA/Forest Service in developing satellite remote sensing techniques for updating the periodic assessment required by the Resource Protection Act.

5. Land productivity: combined with land use activity to monitor and quantify impact of agricultural land use change.

6. Conservation: monitor the affect of conservation practices and water usage.

7. Pollution: monitor and quantify the pollution caused by agriculture practices and determine the effect of pollution on agriculture.

The results of this program will provide state-of-the-art analysis techniques to other research activities within Renewable Resources and will thus complement our existing on-going ,research activities with other agencies in land use and water resources.

CHANGES FROM FY 1979 ESTIMATE:

The increase in FY 1979 funding reflects in Renewable Resources the provisions for initial experimentation to develop production forecasting technology for corn and soybeans; and in Non-Renewable Resources, the provision for Stereosat definition studies and the transfer from the Geodynamics program of topographic and magnetic mapping activities.

BASIS OF FY 1980 ESTIMATE:

Renewable Resources: In F 980, in support of the Agriculture research effort, exploratory experiments based upon research activities conducted in FY 1979 and prior years will be conducted in the U.S. for wheat, barley, corn, and soybean; in India and Australia for wheat; and in the USSR for barley. In addition, supporting research activities will be initiated to improve quantitative estimating techniques for assessing crop, range land, and forest conditions.

Non-Renewable Resources: Principal efforts will be directed toward improving our ability to detect geologic structure and chemical composition and to understand geological processes, thereby enhancing exploration strategies for non-renewable resources. Included are empirical analyses of rock-type interpretation, structural mapping, and interpretation of regional magnetic and gravitational anomalies; development of exploration models; research on vegetation anomalies as indicators of mineralization; studies of the use of active and passive microwave for geologic structure mapping; and the initiation of definition studies for a polar orbiting satellite capable of obtaining global stereo data.

Application Pilot Tests: FY 1980 funds will support seven Application Pilot Tests (APT), five on-going with the Bureau of the Census, California Department of Water Resources, U.S. Forest Service, Cotton Inc., and the St. Regis Paper Company., and two new APT's will be initiated with the Agency for International Development and the U.S. Army Corps of Engineers.

In FY 1980, OERS definition funds will be used to integrate data acquisition requirements with system engineering parameters. Conceptual designs of space and ground systems will be developed and implementation options will be analyzed. Economic and institutional studies will be performed to support pricing policies and private sector involvement. This work will be performed in collaboration with an interagency working group.

Advanced studies in FY 1980 will be performed on a variety of sensors and missions including Multispectral Resource Sampler, Stereosat, Soil Moisture Monitoring Mission, and Earth Resources Synthetic Aperture Radar.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

ENVIRONMENTAL OBSERVATIONS PROGRAM

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Tiros-N	4,100	---	1,200	---	7-23
Nimbus-7	12,210	2,800	3,624	500	7-24
Seasat	14,367	3,000	3,500	---	7-25
Earth radiation budget experiment	---	8,000	7,000	23,000	7-26
Halogen occulation experiment	---	6,100	3,600	8,000	7-28
Stratospheric aerosol and gas experiment	2,400	---	---	---	---
Shuttle/Spacelab payload development	6,040	7,300	7,750	7,400	7-29
Operational satellite improvement program	5,600	6,100	6,100	7,400	7-31
Applied research and data analysis	29,298	31,800	33,876	49,900	7-32
Extended mission operations	1,400	2,500	1,250	5,800	7-35
Upper atmospheric research	(12,080)*	(14,500)*	(14,500)*	15,200	7-36
Total	75,415	67,600	67,900	117,200	

OBJECTIVES AND STATUS:

Understanding the dynamics and limitations of our environment is essential to our long term survival. The objectives of NASA's Environmental Observations Program are to improve our understanding of processes in the atmosphere and oceans, to provide space observation of parameters involved in these processes, and to extend the capabilities to predict environmental phenomena and their interaction with human activities. The interactions among the processes and the interrelationship of the atmosphere, ocean, land and space environments can only be fully studied on a global basis from space. NASA's program includes research efforts plus the development, demonstration and transfer of new technology for global and synoptic measurements. It also includes the use of research satellites for the study of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

*Program transferred from Space Science to Space Applications in January 1979; FY 1979 and prior funding not included in total.

Inasmuch as the physical and chemical processes in any one layer of atmosphere or oceans must be understood in relation to the other layers, NASA has recently combined all of its atmospheric and oceanic studies by transferring the responsibility for the Upper Atmosphere Research Program from the Office of Space Science to the Office of Space and Terrestrial Applications. This transfer will help to assure an integrated NASA atmospheric program, strengthen the Environmental Observations Program, and provide for the maximum interchange of information in the atmospheric research community.

The Environmental Observations Program now includes studies of all the layers of the atmosphere, from the turbopause (100-110 km) down to and including the upper layers of the oceans, and the full range of geographical perspectives, from the local scale to regional and global scales. The program areas include: (1) upper atmospheric research, (2) global weather, (3) severe storms, (4) climate, (5) environmental quality (including stratospheric pollution and tropospheric pollution), and *(6)* oceanic processes (including water pollution, ocean dynamics, ice dynamics, and coastal processes). This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography, and focuses on the special contribution of space derived data. In support of these programs, four spacecraft were launched in 1978--SEASAT, Tiros-N, GOES-3, and Nimbus-7. The Stratospheric Aerosol and Gas Experiment will be launched in 1979, the Halogen Occultation Experiment in 1982 and 1983, and the Earth Radiation Budget Experiment instrumentation on two National Oceanic and Atmospheric Administration (NOAA) meteorological and a NASA dedicated spacecraft during 1982-1984. Valuable research data will also be obtained from experiments to be conducted on Spacelab missions, such as the Atmospheric Cloud Physics Laboratory, and from the Office of Space Science's Solar Mesopheric Explorer.

On a local scale, NASA's program aims at aiding the mission agencies to improve the accuracy of severe storm forecasts and at measuring urban pollution episodes from space. Frost and freeze warnings are one example of the former. NASA field experiments in the southeastern Virginia region demonstrate the utility of NASA sensors for regional air pollution studies. NASA and the Environmental Protection Agency (EPA) have initiated an effort to develop a cooperative plan to demonstrate synoptic coverage of regional air pollution.

In FY 1980, NASA's severe storm research will include analytical studies to improve the basic understanding of storms, the use of storm observations in forecast models, and development of sensors based on the Doppler shifts of reflected radiation. The program will emphasize energy exchanges and fluid flow around storms.

On a regional scale, the Environmental Observations Program addresses: (1) pollution transport in air and water; (2) coastal and cryospheric processes; (3) tracking ocean currents; (4) determining exchange mechanisms of stratospheric and tropospheric air; and, (5) improving remote sensing for synoptic weather forecasts.

In FY 1980, NASA's air quality research will focus on regional tropospheric chemistry, transport dynamics, and possible prediction techniques for air pollution episodes. Also, interhemispheric variations of tropospheric carbon monoxide will be measured from space. An important 1980 thrust is the simultaneous measurement of key species in the chlorine, nitrogen, and hydrogen chemistry families.

The NASA climate effort, in support of the National Climate Program, will emphasize those long-term global measurements and research areas involving atmospheric and oceanic phenomena where space systems can provide a significant contribution to achieving a better understanding of climatological processes.

To provide improved observing systems for the operational meteorological satellite missions, NASA's global weather activities include: support to the GARP Global Weather Experiment; development of improved operational meteorological satellite systems; research into modeling using satellite data; development of improved sensors, improvement of techniques to extract meteorological parameters from remotely sensed data; and conduct of experiments in space.

To achieve maximum utilization of remote observations, NASA will perform numerical sensitivity studies of possible future remote measurements. FY 1980 will see the continuing research toward an advanced meteorological temperature sounder, development of a laser atmospheric profiler, and exploration of wind measurement techniques from space platforms.

NASA and the oceanographic science community have begun to realize the tremendous power that satellites can bring to the study of the world's oceans. The first dedicated oceanographic satellite--SEASAT--was launched in June of 1978. The observations collected during 99 days of successful operation are an important data base which will be analyzed thoroughly by the end of FY 1980. Increased participation by the oceanographers in NASA's program will be supported by numerous activities in FY 1980, such as: (1) a real-time satellite station at the Scripps Institute of Oceanography; (2) large scale oceanic models; (3) joint experiments involving remote observations of the sea surface; (4) ice dynamic studies; and, (5) ocean circulation studies.

In FY 1979 and FY 1980, NASA, NOAA and the DOD are studying the programmatic and technical requirements for a National Oceanic Satellite System (NOSS), which would have the objective of demonstrating, on a limited operational basis, the capability for remote sensing from space to obtain data on such oceanic features as directional wind stress, sea surface topography, ice cap profiles, significant wave height, directional wave spectra, sea ice patters, internal waves, sea surface temperature, and chlorophyll.

In 1980, models of air-sea interactions will be developed and the influence of sea-state on the backscatter of electromagnetic signals will be investigated. Ice dynamics models will be developed to accommodate remote sensor data, and surface truth experiments will improve understanding of microwave sensors for ice. Analyses of coastal phenomena will provide biomass distributions, concentrations, and variations using data from the Nimbus-7 Coastal Zone Color Scanner (CZCS).

The near-term emphasis of NASA climate research is on the design and development of the Earth Radiation Budget Experiment (ERBE). We will continue measurement of the solar constant with Nimbus-6, Nimbus-7, Solar Maximum Mission, Spacelab-1, ERBE, and several sounding rocket calibration flights.

In FY 1980, five areas will be considered for special analytic studies: (1) cloudiness and radiation budget; (2) air/sea interactions; (3) cryospheric processes; (4) hydrological processes; and (5) sun-weather relationships. In addition, studies will be continued on new sensors for precipitation, clouds, and ice. Numerical sensitivity studies will determine the most effective distribution for observations and the most important parameters to be measured. Satellite data sets on the Earth and solar radiation, ozone concentration, rainfall and sea ice will be extended.

In summary, the NASA major near-term thrusts in Environmental Observations are to: (1) understand the physics and chemistry of the atmosphere; (2) detect any global changes in stratospheric ozone; (3) improve measurements of atmospheric temperature, moisture, pressures, winds, and precipitation; (4) utilize Global Weather Experiment data to test models and study error sources; (5) validate severe storm indicators and precursors; (6) analyze satellite data to validate photochemical transport models of the atmosphere (especially the troposphere); (7) study the possibilities for a joint NOAA, NASA and DOD demonstration of an operational system for ocean monitoring; (8) analyze Seasat data for oceanographic information; (9) determine the dynamic behavior of water and ice (coastal zone and deep ocean); (10) carry out special studies of climatic processes, (i.e., aerosols and radiation budget); and, (11) perform sensitivity analyses on other climate observables (cryosphere, air/sea interactions, precipitation, etc.). Together, these comprise NASA's applications of space observations to the understanding and prediction of the behavior of the fluids (air and water) which make up our planet's dynamic environment.

Operational Temperature Sounding Satellite (TTROS-N)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft and support	3,759	---	1,079	---
Sensor development	34	---	---	---
Ground operations	307	---	121	---
Total	4,100	---	1,200	---
Atlas-F (expendable launch vehicles program)	(2,700)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the TIROS-N project is to develop a prototype satellite and sensors capable of meeting stated future requirements of the National Oceanic and Atmospheric Administration (NOAA) for obtaining quantitative data of the Earth's atmosphere on a daily basis. TIROS-N was successfully launched on October 13, 1978. The data are being used in numerical models of the Earth's atmosphere whose solutions are expected to significantly improve long-range weather predictions. The payload consists of six sensors: a High Resolution Infrared Sounder is measuring the temperature and moisture profiles at several altitudes in the troposphere and lower stratosphere; a Stratospheric Sounding Unit, provided by the United Kingdom at its own expense, is providing similar data in the upper stratosphere; a Microwave Sounding Unit is obtaining atmospheric temperature measurements even in the presence of clouds; the Advanced Very High Resolution Radiometer is providing detailed cloud images as well as sea-surface and cloud-top temperatures for use in improving the accuracy of 12-to-36 hour weather forecasts; a Data Collection System, furnished by France at its own expense, is gathering environmental data from remote platforms located throughout the world; and finally, a Space Environment Monitor is making daily observations of electron, proton, and X-ray activity in the near-Earth space environment.

CHANGES FROM 1979 BUDGET ESTIMATE:

The increase in the FY 1979 budget estimate is due to the TIROS-N launch delay from May until October, which resulted from launch pad conflicts and technical problems with the spacecraft.

Air Pollution and Oceanographic Observing Satellite (Nimbus-7)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	3,700	600	---	---
Sensors and data analysis	4,610	1,330	2,324	---
Ground support	3,900	870	1,300	500
Total	12,210	2,800	3,624	500

OBJECTIVES AND STATUS:

The detection and measurement of atmospheric and water pollution constituents on a global basis require the collection of remotely-sensed repetitive data from space. The Nimbus-7 spacecraft, successfully launched in October 1978, provides this capability on this scale for the first time.

Four of the spacecraft sensors detect and measure constituents related to atmospheric pollution, specifically constituent gases'and particulates. Taken on a global basis, these measurements will be used to analyze pollutant concentrations and movements to determine their sources and life cycles.

Two other sensors will be used to obtain high spatial resolution ocean color measurements near the coastlines (relating to nutrients, pollutants, and salinity) and microwave measurements of the ocean/atmosphere interface characteristics. The data is useful in applications such as ocean-food investigations and survey of ocean pollution as well as knowledge of the interactions between the ocean, the atmosphere, and the Sun.

The remaining spacecraft sensor is continuing the collection of data pertaining to the Earth's radiation budget begun on earlier Nimbus spacecraft. This effort extends the long-term baseline of data leading to a better understanding of the Earth's thermal balance.

CHANGES FROM N 1979 BUDGET ESTIMATE:

The Nimbus-7 launch was delayed from August to October 1978 based on launch facility availability and technical problems with the spacecraft tape recorder. Some effort originally planned for N 1978 was therefore deferred into FY 1979.

BASIS OF FY 1980 ESTIMATE:

The delayed launch will result in the last month of the baseline Nimbus-7 project mission operations occurring in FY 1980. Funds requested in FY 1980 will support mission operations for that month.

Ocean Dynamics Satellite (SEASAT)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft and support	9,106	---	---	---
Sensor development	1,720	---	---	---
Mission operations	3,541	3,000	3,500	---
Total	14,367	3,000	3,500	---
Atlas-F (expendable launch vehicles programs)	(3,600)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the Ocean Dynamics Satellite, SEASAT, is to provide a proof-of-concept demonstration for the use of satellite-acquired data for the detection, monitoring, and forecasting of ocean conditions. Specific applications being explored are the use of data on wave height, wind direction and speed, and sea surface temperature for improved forecasting of ocean conditions for ship routing, fisheries management, off-shore gas and mining operations, and for synoptic improvements in short range global weather forecasting.

SEASAT-1 was successfully launched from the Western Test Range at Vandenburg Air Force Base on June 26, 1978. After 106 days in orbit, a massive power failure resulted in loss of all onboard data and effectively terminated the spacecraft mission. However, during the 106 days, two major surface truth support activities were conducted, thus significantly enhancing the value of the SEASAT data set. The SEASAT data set is currently being analyzed; the assessment at this time is that the major part of the project's objectives will be satisfactorily accomplished.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase in the FY 1979 budget estimate is primarily due to the support of analysis activities associated with the SEASAT Mission Failure Investigation Board.

Earth Radiation Budget Experiment

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	---	4,600	3,400	10,700
Sensors	---	3,400	3,300	11,800
Mission operations and data analysis	---	---	300	500
Total	---	8,000	7,000	23,000

OBJECTIVES AND STATUS:

More solar energy is absorbed by some regions of the Earth than by others. At the same time, more thermal energy is radiated into space by some regions than others. This differential heating is thought to be the driving force that sets the atmospheric winds and ocean currents into motion so as to transfer heat from warmer areas to cooler areas. The excess in the amount of solar energy absorbed over the thermal energy radiated to space continually changes for any given region, depending on the time of year, degree of cloudiness, snow and ice cover, atmospheric dust and aerosols, and properties and conditions of the surface.

The objective of the Earth Radiation Budget Experiment is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insights as to reasons for climatic fluctuations.

Experimental Earth radiation budget instruments have flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. They also indicate the need for more stringent calibration of the sensors. Two NOAA satellites of the Tiros-N series will be flown in sun-synchronous orbits equipped with identical Earth Radiation Budget instruments. One of the NOAA satellites will have a morning equatorial passage time, while the other will have a mid-afternoon passage time. Adequate mid-latitude and equatorial coverage requires an additional satellite. Therefore, a third set of instruments will be flown on a NASA dedicated spacecraft in a 46° inclined orbit plane. Each equatorial region must be viewed at least once each month at each hour of the day, and the orbit altitudes and instrument view angles must be known to permit: geographical location of the radiometer footprints. Together, the three satellites will provide accurate measurements of the monthly average radiation balance with regional, zonal, and global resolutions. The planned launch dates are 1982-1984 for the NOAA satellites and 1983 for the NASA dedicated satellite.

The scientific objectives and measurement requirements have been developed by a joint NOAA/NASA team of scientists that included leading scientists from the university community and other non-Government organizations. These requirements have been reviewed by a committee of the National Academy of Science. During FY 1979 the ERBE instrument specification and associated Request for Proposal package was released to potential contractors; selection of the contractor is scheduled for June 1979. Engineering design of the instruments is in process. Design modifications to accommodate the ERBE instruments on Tiros-N/NOAA spacecraft bus will be accomplished and the contract for the NASA dedicated spacecraft bus and Shuttle interface will be negotiated. Data processing algorithms are being defined by the ERBE experiment team.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Total estimated funding for ERBE remains the same but $1 million was rephased from FY 1979 to FY 1980 based on better estimates of the project needs for the modification of the Tiros-N/NOAA spacecraft and for the instrument contract.

BASIS OF THE FY 1980 ESTIMATE:

FY 1980 funding will be used to complete the major portion of the Tiros-N/NOAA spacecraft modifications to accommodate the ERBE instrument, to continue the design and development of the ERBE instruments, and to support the initial fabrication of the NASA dedicated spacecraft plus the design of the Shuttle/spacecraft interface hardware. ERBE experiment team members are scheduled to be selected by mid-year and funding support for data processing, algorithms and model software effort for the team will be provided.

Halogen Occultation Experiment

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Sensor development	---	6,100	3,600	8,000

OBJECTIVES AND STATUS:

The Halogen Occultation Experiment (HALOE) will provide global stratospheric vertical concentration profiles of key chemical species involved in the catalytic destruction of ozone due to chlorine compounds. These measurements will assist in estimating the depletion of stratospheric ozone due to natural and man-made causes involving chlorofluoromethanes (CFM's). Specific objectives of HALOE are: (1) to monitor globally the vertical profiles of concentrations of stratospheric hydrogen chloride, hydrogen fluoride, and water and other trace gases of importance to the chlorine chemistry; and (2) to use the measured data (a) in obtaining horizontal and vertical maps of gas concentrations; (b) in performing a chlorine source analysis; (c) in validation of chemical and dynamic models describing the effects of CFM's on the ozone layer; and (d) in predicting ozone depletion and depletion rate due to chlorine build-up in the stratosphere.

An initial test of the engineering model instrument is being planned for flight on a Shuttle mission to demonstrate the validity of the measurement technique in a space environinent and to evaluate the instrument operating parameters. A longer duration mission of one to two years will take place on the Earth Radiation Budget Experiment mission in 1983. Conceptual design of the HALOE instrument has been accomplished under the Advanced Applications Flight Experiments (AAFE) program. Design of the spaceflight instrument is in progress, with fabrication scheduled to begin in July 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Earlier estimates were based on plans for two flights of this instrument on short-duration Shuttle missions. Due to adjustments in the Shuttle launch schedule and a re-evaluation of the need for two HALOE checkout flights, only one Shuttle flight of the HALOE is planned prior to the Earth Radiation Budget Experiment mission. The project funding has been revised consistent with this plan.

BASIS FOR FY 1980 ESTIMATE:

In 1980, fabrication of the engineering model unit to be flown on the Shuttle will continue, leading to delivery of the instrument for integration in mid-1981. Detailed design of major subsystems of the flight unit for the Earth Radiation Budget Experiment will also be supported with FY 1980 funds. Science activities will be focused on modeling techniques and development of the inversion algorithms.

Shuttle/Spacelab Payload Development (Environmental Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Measurement of air pollutants from satellites (MAPS)..	740	600	500	800
Atmospheric trace molecules observed by spectroscopy (ATMOS)	2,600	2,300	3,750	3,200
Atmospheric cloud physics laboratory (ACPL)	2,700	4,400	3,500	3,400
Total..	6,040	7,300	7,750	7,400

OBJECTIVES AND STATUS:

The Space Transportation System offers the opportunity for frequent, short-duration flights for instruments and associated experiments. The Environmental Observations Program is incorporating this new capability in order to capitalize on three important facets: (1) early tests, checkout and design refinement of remote sensing instruments whose ultimate use is in a long-duration monitoring system on a free-flying satellite; (2) short-term data gathering of atmospheric and environmental processes for basic research and analysis where long-term observation is not necessary or is impractical; and (3) research into processes which cannot be accomplished effectively in ground-based laboratories because of the effects of gravity. The three efforts presently under development are: Measurement of Air Pollutants from Satellites (MAPS); Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS); and Atmospheric Cloud Physics Laboratory (ACPL).

Measurement of Air Pollutants from Satellites (MAPS) -- This experiment, selected for the payload complement for the first Office of Space and Terrestrial Applications (OSTA) mission on the Shuttle, will be the first test of using gas filter correlation radiometry for tropospheric measurements from orbit. Mid- and upper-tropospheric carbon monoxide will be measured and will be used as a tracer to observe and define the extent of interhemispheric mass transport in the lower atmosphere. Results will be used by researchers to: (1) test the accuracy of photochemical model calculations; (2) evaluate the relative magnitude of natural and man-made carbon monoxide sources; and (3) refine current estimates of interhemispheric mass exchange.

The instrument itself is derived from a brass-board model originally developed as a candidate for the Nimbus-7 mission. It was subsequently modified for aircraft experimentation and has been used successfully in this mode to map pollution plumes in industrial areas. The instrument for the Orbital Flight Tests is scheduled for delivery to Langley Research Center in early 1979 for calibration and instrument characteristics testing. The integration testing will begin in 1979 leading to a launch in mid-1980.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) -- The objective of this investigation is to make detailed measurements of gaseous constituents in the Earth's upper atmosphere using the techniques of infrared absorption spectroscopy. Specific constituents to be measured are hydrogen chloride, water, ammonia, methane, nitrous oxide, deuterium oxide, and ozone. These data will allow the determination of the compositional structure of the upper atmosphere, including the ozone layer, and its spatial variability on a global scale. The high resolution, calibrated spectral information will also be utilized for design criteria for future instruments whose objective is to monitor a specific constituent on a long-term basis.

Early versions of this high speed interferomter have been tested in the laboratory, on balloonflights, and on aircraft. With the selection of this experiment for flight on Spacelab 1, a contract was signed in late 1977. The preliminary design review has been held and the project is proceeding on a schedule compatible with the planned Spacelab 1 mission.

Atmospheric Cloud Physics Laboratory (ACPL) -- The objective is to perform research into the very small-scale (microphysical) atmospheric cloud processes. Experimentation in Earth-based laboratories related to processes that occur inside the clouds is very difficult because gravity-driven convection and droplet setting begin immediately after a cloud is formed. This makes observation of the critical droplet-forming stage nearly impossible on Earth. This program will provide a unique, multipurpose laboratory facility for flight in the habitable Spacelab module to achieve a low-gravity environment for experimentation. In orbit, experiments will be performed by a payload specialist in close coordination with the ground-based investigators. Formation of clouds under these conditions will allow measurement of their properties over relatively long periods of time.

The objectives of the first (ACPL-1) flight will be to validate and establish baseline system characteristics, to investigate the microphysics of warm cloud processes, and to observe ice crystal growth in zero gravity under carefully controlled conditions. The Preliminary Design Review was held in mid-1978. All major subcontracts have been let, the engineering model components are on order, and detailed design of the system is in progress. A preliminary design review of the ACPL-1 experiments has been completed and special requirements factored into the baseline design.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Measurement of Air Pollutants from Satellites -- The decrease resulted from a rephasing of funding requirements.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) -- The original concept for mounting this instrument was inside the Spacelab habitable model. Due to the design and operational complexity associated with this configuration and the restricted opportunities for re-flight in this mode, a decision has been made to design the instrument for pallet mounting.

Atmospheric Cloud Physics Laboratory (ACPL) -- Consistent with the planned Schuttle schedule, the initial flight of the ACPL will take place later than anticipated. The activities to modify the laboratory experiments to investigate the formation of ice clouds during expansions of moist air will be postponed.

BASIS OF FY 1980 ESTIMATE:

Measurement of Air Pollutants from Satellites (MAPS) -- The FY 1980 activities will be focused on support to the launch and mission operations activities and initial data analysis. Real time support will be required for the integration process and flight operations. Data analysis and involvement of the principal investigator team will begin within one month after completion of the mission.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) -- Delivery of the instrument from the contractor is scheduled for early 1980. In the period just prior to delivery, the final system integration will occur and the instrument performance and environmental testing will be accomplished. After receipt at JPL, an internal verification and familiarization program will be performed by the experiment team to establish baseline characteristics of the instrument. The software for data analysis will be generated and validated during this time period. Delivery of the instrument for integration into the Shuttle payload is scheduled for late 1980.

Atmospheric Cloud Physics Laboratory (ACPL) -- During FY 1980, the laboratory critical design review will be completed and development testing of the engineering unit accomplished. Payload specialist training will be conducted at the prime contractor's plant on the engineering unit hardware. The principal investigators (PI's) for the first flight of ACPL will conduct experiment testing on the laboratory compatibility. The engineering unit hardware will be refurbished and qualification tests will be conducted. PI's selected for research in cold-cloud processes will continue experiment development under previously initiated contracts.

Operational Satellite Improvement Program (OSIP)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Research and development for improvement of operational satellite systems	5,600	6,100	6,100	7,400

OBJECTIVES AND STATUS:

The objective of the operational satellite improvement program is to carry out the research and development activities which will provide advanced sensors, spacecraft subsystems, and ground equipment for present and future operational satellite systems.

Current developments include modifications of the Advanced Very High Resolution Radiometer to add a fifth channel for improved sea surface temperature measurements; modification of the Nimbus High Resolution Infrared Sounder for flight on NOAA operational spacecraft; modification of the Nimbus Solar Backscatter Ultraviolet (SBUV) instrument for monitoring changes in global ozone; and the development of the VISSR Atmospheric Sounder for obtaining temperature profiles from geostationary orbit. All of these developments are nearing completion; the sensors are scheduled for flight between now and late 1982.

BASIS FOR FY 1980 ESTIMATE:

FY 1980 funds will be used to complete development effort on the VISSR Atmospheric Sounder for flight on GOES-D, which is now scheduled for launch in mid-1980. In addition, work will continue on modifications to the Nimbus SBW to be used as an ozone monitor in the NOAA operational satellite system beginning in the 1982-83 time period. Effort will also be initiated in defining spacecraft, instruments, and ground systems applicable to meeting the needs of the operational system in shifting over to the Shuttle mode of operations in the 1985 time period.

Applied Research and Data Analysis (Environmental Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Applied research and data analysis in:				
Global weather (including GARP)	8,300	8,600	8,500	10,700
Climate	2,500	4,200	4,200	8,500
Severe storms	3,500	3,700	3,700	5,200
Environmental quality	9,200	8,400	8,400	11,100
Ocean processes	5,798	6,900	7,576	11,400
System 85 definition	---	---	---	1,500
National oceanic satellite system (NOSS) definition	---	---	1,500	1,500
Total	29,298	31,800	33,876	49,900

OBJECTIVES AND STATUS:

The objectives of this program are to improve our understanding of atmospheric and oceanic processes in order to extend our capabilities to predict environmental phenomena and their interaction with human activities. This includes research and the development, demonstration and transfer of new technology in the area of space systems capable of making global and/or synoptic measurements of the atmosphere on an operational basis. It also includes the development and use of research satellites to provide unique perspective of space for the study of the radiative, chemical and dynamic processes occuring in the atmosphere and oceans, the interactions among these processes, and the interrelation of the atmosphere, ocean, land and space environments.

The scope of the program varies from the small spatial and temporal scales of severe local storms and urban pollution episodes to the global spatial scale and long-time scales of climate. Our integrated program permits a focus on the interrelationship between the classically diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics and oceanography, as well as individually upon these disciplines themselves.

On short time scales, the program aims at localizing and improving the accuracy of severe storm forecasts and warnings, and at developing the capability to measure and characterize severe weather and urban pollution episodes from space. On a regional scale we are addressing concerns with the transport of pollution in the air and water, coastal and cryospheric processes, tracking the'fluctuations in major ocean currents, determining the mechanisms for exchanges of stratospheric and tropospheric air and improving synoptic weather forecasts through better remote sensing techniques.

Capitalizing on the global perspective of space, the program objectives are to. study tropospheric and stratospheric pollution, to measure the radiative budget of our planet, to improve numerical weather prediction, to determine the morphology of lightning and severe storm occurrence, and to develop and demonstrate the capability for remotely sensing ocean surface properties, the air-sea interface, and the distribution of biomass in the uppermost layer of the ocean. The climate element of the program takes a long term perspective of the phenomena of the atmosphere and ocean with the objective of determining, interpreting, and obtaining those global data sets from spaceborne platforms which, in cooperation with other related programs, will provide a long term predictive capability.

To a varying extent, each of the elements of the program supports the development and demonstrations of remote sensing technology, the development of algorithms to extract geophysical parameters from remote data, suborbital and ground based experiments to measure fundamental properties and processes of the system and provide a base for remote sensor development, fundamental research into the processes at work in the environment and the development of models which express the current understanding of all or part of this system and provide a predictive capability.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Funding in FY 1979 has been increased by approximately $2 million to provide for more timely, in-depth analysis of data obtained from SEASAT, and to support preliminary definition activities for the National Oceanic Satellite System.

BASIS FOR FY 1980 ESTIMATE:

NASA has successfully orbited the Tiros-N satellite which is essential to the gathering of atmospheric and oceanic observations for the First GARP Global Weather Experiment (FGGE) covering a one-year period which commenced December 1, 1978. NASA, NSF, NOAA and others are participating in FGGE. NASA will support numerous data analysis experiments and extended meteorological soundings. Research will be supported for wind and improved temperature measurements from remote platforms. NASA will also undertake an enhanced research effort to develop microwave pressure measurements and develop technology for advanced sensor concepts, algorithm and data processing techniques.

In the climate area, NASA will conduct special studies of climate processes with emphasis on the Earth's radiation budget and aerosol effects. Data sets related to these studies will be developed and NASA's climate modeling capabilities will be expanded in order to perform the necessary sensitivity studies of climate parameters. Data sets will be developed, and analytical studies will be carried out on precipitation and air/sea interactions and their contributions to climate. New sensors for remote measurements of clouds, precipitation and ice will be investigated and simulations for future global observational systems will be performed.

Analytical studies on severe storms will permit the best analysis of observation data and evaluation of severe storms forecast models. A doppler sensor for wind field observations will be developed and studies conducted on storm precursors. Studies will be performed in an attempt to understand the basic energy exchanges, fluid flow configurations and to determine if there are any ionospheric indicators or precursors to severe storms.

In the environmental quality area, studies will be continued on ozone climatology, global atmospheric chemical cycles, circulation and diffusion in water, and regional tropospheric dynamics. Rocket and balloon ground truth measurements will be provided for the Nimbus-7 and Stratospheric Aerosol, and Gas Experiment and the data investigations conducted for these extended missions. Improved limb scanning, gas filter correlation, and multi-spectral remote sensors will be investigated. Technology improvements will be pursued in active laser and microwave techniques for direct and remote measurements in the troposphere and stratosphere.

Studies of oceanic processes will include micro-scale and meso-scale surface and subsurface dynamics, ice dynamics, ocean circulation and topography and improved data processing techniques. Follow-on investigations will be supported on the existing SEASAT data. Mission planning studies will be performed on coastal zone observations and the cryosphere. Research will be conducted on advanced microwave sensors for improved water and ice observations. Advanced studies with NOAA and DOD for future research and operational ocean related missions will continue.

FY 1980 funds will also provide for definition studies of the next generation meteorological satellite systems (Systems 85) and a continuation of the interagency studies of the programmatic and technical requirements for a National Oceanic Satellite System. These studies will include instrument definition and overall systems requirements definition.

Extended Missions Operations (Environmental Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Operations for the extended missions of:				
Nimbus 5-7..	900	---	---	5,200
Stratospheric aerosol and gas experiment	---	---	700	600
Geodynamic experimental ocean satellite	500	500	550	---
SEASAT	---	2,000	---	---
Total	1,400	2,500	1,250	5,800

OBJECTIVES AND STATUS:

Nimbus-7 was launched in October 1978. Extending the mission through FY 1980 will provide unprecedented baseline atmospheric and surface data. Data which has been only initially analyzed can yield vital information when additional analyses and user investigations are performed and additional corroborative data are collected. Urgent needs continue for these data which include, among others, global precipitation, soil moisture, and snow-and-ice-cover data from the microwave sensors from Nimbus-5, -5, and -7, and important data on the Earth's radiation budget from both Nimbus-6 and -7. These data, when properly reduced to useful physical parameters and furnished to the scientific and data-user community in practical forms are expected to be applied directly to specific national and global problems. Such problems include the trend of regional and world weather, severe storm analysis and prediction, and numerical forecast model improvements. The satellite carrying the Stratospheric Aerosol and Gas Experiment (SAGE) instrument, to be launched in early 1979, will provide for essentially global monitoring of ozone and aerosols by solar occultation means.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease in the FY 1979 SEASAT budget estimate results primarily from the failure of the SEASAT spacecraft after 106 days of successful in-orbit operation, 99 of which were data-collecting days. The funding originally planned for extended operations will be used for SEASAT data utiliztion which is conducted within the Applied Research and Data Analysis area. The increase for SAGE is for support and to provide an additional six months of mission operations, data processing and data analysis in order to provide one full year of mission support. The increase for the Geodynamic Experimental Ocean Satellite results from the consolidation of science support for the mission.

BASIS OF FY 1980 ESTIMATE:

This funding will provide for continuing Nimbus–7 space flight operations, data collection, processing and formatting into user products, and distribution, and for continuing Nimbus–5 and –6 operations. By extending the SAGE mission through the winter of FY 1980, a second set of winter transport data will be obtained, which will aid in the longer range evaluation of the effects of man–made and natural effluents on the ozone and the contribution of aerosols to ozone depletion. The funding requested will also support the selected investigators in furthering their analyses of the data.

Upper Atmospheric Research

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Research support	(11,600)	(11,900)	(11,900)	11,400
Upper atmospheric research balloon program	(160)	(1,000)	(1,000)	1,100
Spacelab payload definition.	(320)	(600)	(600)	500
Spacelab payload development	(---)	(1,000)	(1,000)	2,200
Total	(12,080)"	(14,500)*	(14,500)*	15,200

* Program transferred from Space Science to Space Applications, January 1979; FY 1979 and prior funding not included in totals.

OBJECTIVES AND STATUS:

The upper atmospheric research program is primarily aimed at pursuing a comprehensive effort toward under–

standing the Earth's upper atmosphere. In particular, the goal is the improved prediction of man's impact upon the ozone layer and the effects of changes in the upper atmosphere upon our environment. In order to accomplish this, efforts are underway: (1) to improve upper atmospheric models, validate them and assess their uncertainties; (2) to measure minor chemical constituents, temperature, and radiation fields in the upper atmosphere using balloon, rocket, and aircraft experiment platforms as well as ground-based measurements; (3) to develop sensors capable of remotely sensing all aspects of the upper atmosphere from space; (4) to assemble and maintain the existing long-term data base of stratospheric ozone measurements made by all types of techniques, including satellites, for the purpose of uncovering long-time scale natural variations and detecting man-made ozone changes; and (5) to carry out laboratory kinetics and spectroscopy studies to support these other activities.

Significant new simultaneous measurements of numerous stratospheric species have been accomplished and several coordinated balloon flights have been completed. Approximately 130 tasks are supported, involving elements of the Government, university, and industrial research communities. Results from theoretical studies have emphasized the close coupling of the nitrogen, hydrogen and chlorine compounds. New laboratory results have provided improved data required for models and the interpretation from our field measurements program. New measurement techniques have been demonstrated. A reaction rate panel has been established. An extensive workshop is scheduled to assess the status of the ozone depletion problem and planning is underway for an Upper Atmospheric Research Satellites (UARS) program to provide a comprehensive investigation of the energetics, composition, and dynamics of the stratosphere and mesosphere.

The balloon support program provides for instrument development and testing, and provides for a large number of direct and remote atmospheric measurements in the altitude range up to about forty-five kilometers.

Initiation of activities for follow-on principal investigator class payloads beyond Spacelab-3 are underway. Definition studies for several multi-user facility instruments are being conducted.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, a comprehensive program, directed toward understanding the upper atmosphere, will continue and intensify. In particular, the development of models which couple radiative, dynamic, and chemical processes will continue; the confirmation of chemical mechanisms by simultaneous measurements of stratospheric trace species will be extended; improvements in the laboratory kinetics and spectroscopy data base will be sought; and new and improved techniques will be developed for detecting additional trace species and remotely measuring winds. The research program will be extended into the mesosphere because knowledge of the coupling between these regions is necessary for understanding the complex interactions between radiation, chemistry, and dynamics in the upper atmosphere and the relationship between solor variations and terrestrial weather and climate. These studies will support the International Middle Atmosphere Program (MAP) in the mid-1980's.

The balloon program will be continued at about the current level of approximately 45 flights per year. Evaluation and selection of atmospheric experiments for follow-on Spacelab missions will be completed. Definition studies for a Spacelab LIDAR system and a cryogenically-cooled, limb-scanning interferometer radiometer (CLIR) will be continued.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

APPLICATIONS SYSTEMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Airborne instrumentation research program..	9,100	5,800	5,800	10,300	7-39
Data management	2,000	1,500	1,500	1,500	7-39
Applications data service definition....	---	---	---	2,400	7-40
Shuttle/Spacelab mission design and integration......	2,240	6,900	6,400	8,300	7-41
NASA integrated payload planning	(4,000)*	4,000	2,000	1,700	7-41
Total	13,340	18,200	15,700	24,200	
Space Transportation System Operations................	(---)	(2,600)	(2,600)	(18,000)	

(*Funded under Space Flight Operations in FY 1978 and prior years.)

OBJECTIVES AND STATUS:

Applications Systems provides support in the areas of flight system suppor , data sys ems, and integrated payload planning. In the area of flight system support are included both research aircraft and payload integration for Shuttle/Spacelab missions. The data systems activity includes the overview of all data management activities on a program-wide basis, as well as definition activities associated with the Applications Data Service. The integrated payload planning function includes the analysis and formulation of all NASA Shuttle payload requirements for the Space Transportation System.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars			
Airborne Instrumentation Research Program (AIRP). .. .	9,100	5,800	5,800	10,300

OBJECTIVES AND STATUS:

The objective is to provide airborne research facilities for the definition and testing of remote sensing instruments; the development and demonstration of remote sensing interpretive techniques; the verification of data acquired by spacecraft sensors; and for the direct sensing measurements for stratospheric research programs. Capabilities provided include five research aircraft, airborne remote sensing instruments, and data processing equipment and services.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will be used to conduct airborne remote and direct sensing measurement flights in support of FY 1980 research requirements emanating from resource observations and environmental observations programs. Projected flight capability is designed to meet major objectives and program thrusts at a level of funding commensurate with accomplishing priority needs. The increase in the funding level from FY 1979 to FY 1980 reflects a change in the management approach to include flight peculiar costs within the project. In FY 1980, all airborne research operating costs will be funded through the Airborne Instrumentation Research Program.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Data Management	2,000	1,500	1,500	1,500

OBJECTIVES AND STATUS:

The objective of the data management effort is to define needs for extension of current technology to accommodate increased volume, complexity, and the concurrent high rates of data, and to reduce origin-to-user transmission times. Users must also be provided with improved capabilities for rapidly storing and retrieving the required data products. An understanding of the current and near-term future technology exists and longer range technology needs are being analyzed.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, modeling efforts will be completed on data/information products to demonstrate data compressibility and effort will be continued to assure that advanced data technology is developed. Study efforts will begin on cross-correlative multi-disciplinary data information overlay techniques, mosaicking and handling textural data for large data sets.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Applications Data Service Definition..............	---	---	---	2,400

OBJECTIVES AND STATUS

The objective of the Applications Data Service (ADS) definition activity is to analyze approaches for meeting economically and efficiently future applications data access and integration needs. In the 1980's, effective use of information gained from multiple sources is key to the users success in dealing with large scale modeling in agriculture, ocean studies, and weather and climate forecasting. This requires timely access to and integration of data from a dozen or more interdisciplinary sources.

The ADS will be planned to build upon existing and planned applications data systems, encourage the convergence of those systems and their products into a compatible and integrated structure through the definition of data'and data systems standards, and to develop a network service for data transmission and integration.

ADS preliminary requirements, concept and feasibility studies presently are underway and will be completed by the end of FY 1979.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will be used to define standards and to initiate contracts for ADS network service definition. Completion of standards definition by the end of N 1980 will allow these data and data systems standards to be implemented in the major next generation systems being defined in the areas of resource observations and environmental observations. The definition activities are expected to take two years.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Shuttle/Spacelab Mission Design and Integration......	2,240	6,900	6,400	8,300

OBJECTIVES AND STATUS:

The objectives of the Mission Design and Integration activity are to plan, design, and implement missions in response to experiment requirements. These activities include integrating instruments into attached payload carriers and conducting the associated flight and ground operations. Preparations are in progress in support of the applications experiments and instruments to be flown during the Space Shuttle orbital flight test missions. In addition, activities in support of the applications payloads planned for Spacelab-3 are proceeding. Efforts for follow-on missions are in various stages of planning and definition of experiment interfaces.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current estimate for FY 1979 is based on rephasing of activities consistent with the delay in the near-term Space Transportation System missions.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funds are required to support ground and flight mission management operations for the applications experiments to be conducted during the Shuttle orbital flight test missions. Included are the Shuttle imaging radar and multispectral infrared radiometer instruments and the measurement of air pollutants from satellites and the ocean color experiment. Progress will continue in support of the space processing and atmospheric cloud physics laboratory experiments to be carried out during the Spacelab-3 mission. In addition mission planning, design, and integration efforts for follow-on applications experiments will be underway. These Cfforts are phased to meet the mission activity level to support experiments currently under development.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
NASA Integrated Payload Planning.....................	(4,000)	4,000	2,000	1,700

OBJECTIVES AND STATUS:

The objectives of integrated payload planning are to coordinate and consolidate NASA's plans for early Space Transportation System (STS) missions to ensure hardware and operational compatibility between the payloads and the STS elements. The FY 1979 effort continues tasks directed toward determining the most economical and effective means of utilizing the STS and assuring payload and STS compatibility. Studies are providing for completion or additional definition of key payload/STS interfaces, mission planning, and integration processes. Support is also being provided for the analysis of requirements for physical (Level IV) integration of payloads.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The reduction in planned payload and mission planning activities for FY 1979 is due to rescheduling of the first STS missions and the planned near-term Spacelab missions.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, those tasks will be identified or continued which are essential to establishing the most economical and effective means of utilizing the STS and assuring hardware and operational compatibility between payloads and STS elements; these tasks will also clearly be multi-program or generic in nature and not within the cognizance of any one program area. Particular areas of concern will be clarifying specific aspects of STS accommodations for payloads and the impact of Level IV decisions on the integration flow interfaces between the STS and payloads. In addition, payload requirements for future STS augmentation or modification will be analyzed to ensure that the most economical and effective utilization of the STS is planned.

BASIS OF FY 1980 FUNDING REOUIREMENTS:

TECHNOLOGY TRANSFER

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Applications systems verification and transfer.....	(1,200)	1,150	1,150	1,700
Regional remote sensing applications...............	2,700	2,500	3,500	3,800
User requirements and supporting activities........	5,600	5,500	4,500	4,800
Civil systems....................................	2,100	1,800	1,800	---
Total..	10,400	10,950	10,950	10,300

OBJECTIVES AND STATUS:

The objectives of the remote sensing Technology Transfer program are to provide for the validation, transfer and widespread dissemination of proven technology applications to operational use.

The Applications Systems Verification and Transfer (ASVT) program conducts the demonstration, verification and transfer of total applications systems in a representative user setting and with participating user organizations, emphasizing cost reduction and system compatibility with the user setting. The program is increasing the awareness and use of remote sensing by other Federal agencies and by state governments. Projects are now underway with the Corps of Engineers, the Pacific Northwest and Appalachian Regional Commissions, the State of Texas, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey. Those projects are being supplemented with an additional project with the National Park Service in FY 1979.

Through the Regional Remote Sensing Applications Program, over 500 state agency personnel have undergone training and/or orientation programs since January 1977. Multi-disciplinary demonstration projects now involving seventeen states are being conducted, and are providing these states with a firm basis for evaluating the potential for operational use of remote sensing technology. In addition, follow-on assistance programs are helping an additional four states establish operational programs.

Under User Requirements and supporting activities, continuing communciations are maintained between NASA and the user community to determine user needs, inform users of existing and planned technological capabilities, obtain external evaluations of Space Applications programs for planning purposes, and develop program awareness and technical capabilities in educational institutions. In the past year, we have established formal interfaces with national and representative organizations (National Conference of State Legislatures, National Governors Association) that have significantly focussed and accelerated state government interest in technology transfer through increased awareness and establishment of two-way communications. Newly established communications with the private sector are aimed at developing increased cooperation between NASA remote sensing programs and industry suppliers and stabilizing the sources of future assistance for operational users of remote sensing. We are continuing to encourage the development of geographically-distributed university capabilities to demonstrate the practical benefits of remote sensing through the conduct of research, education and public service activities. About twenty universities are currently participating in the program, with recent additions expanding the technical area of interest from remote sensing to include space processing.

Technology transfer engineering projects conducted within the Civil Systems program have been transferred to the Technoloty Utilization Program to consolidate all Terrestrial Applications engineering projects.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The total FY 1979 estimate for this program element has not changed. However, a reallocation of $1 million from User Requirements and supporting activities to the Regional Remote Sensing Applications Program in FY 1979 was accomplished to reflect more clearly the division between those activities that are national in scope (retained in User Requirements and supporting activities) and those programs that are intrinsically part of field center (Regional) programs.

BASIS OF FY 1980 ESTIMATE:

Major emphasis for FY 1980 will be in the following areas:

Demonstration projects (ASVT's) with the State of Texas (Natural Resources Inventory/Monitoring) and the Appalachian Regional Commission (lineament analysis/shale deposit detection) will be completed in FY 1980, as will the operational implementation of the DAM (water impoundment inventory) capability with the Corps of Engineers. In FY 1980, approximately four new ASVT's will be initiated. Program thrusts in FY 1980 will address more advanced geo-based information systems and private sector applications such as with architect/engineering consultants, geothermal exploration companies and agro-business. In addition, in FY 1980 private industry will be utilized more fully in conducting projects with users.

Under the Regional Remote Sensing Applications program the transfer of Landsat applications technology to state governments will be continued through established training, demonstration and technical assistance projects. Programs in an estimated eight to ten states will be completed in FY 1980. Follow-on projects and full scale demonstrations (for which preliminary work will be completed in FY 1979) in approximately fifteen states, will be supplemented by the initiation of programs in four to five additional states. Liaison training and prototype demonstration projects will be initiated with representative substate user groups, such as counties and regional councils. As with the ASVT program, increased reliance will be placed on enhancing private sector/user interfaces through cooperative activities.

The User Requirements and supporting activities effort will continue the formal institutional relationship with the National Governors Association (NGA) and the National Conference of State Legislatures (NCSL) with emphasis on the development of a long term plan for NASA, state and local activities; provide for an increasing involvement of the private sector in NASA's transfer efforts as both a user and a producer/supplier; and emphasize user awareness and the requirements of the regional and local governments. Supporting program studies will include evaluation of the human and institutional factors in the transfer process and an evaluation of incentives to increase private industry involvement in remote sensing. In addition, it is planned to continue to phase in new universities (two to three in FY 1980) as other programs are completed. FY 1980 activities will address the likely need for expanding program coverage to new disciplines such as geology, weather-climate, atmospheric applications, etc. Selection of new universities and of tasks to be conducted will be made in concert with the Regional Remote Sensing Applications Program to reinforce the establishment of capabilities at state and local levels to use remote sensing data to meet operational needs.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

MATERIALS PROCESSING IN SPACE

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Space processing applications rocket (SPAR) project..	3,900	3,600	3,600	2,100	7-47
Applied research and data analysis....................	4,350	4,400	4,400	6,900	7-48
Shuttle/Spacelab payload development..................	5,400	12,400	12,400	10,800	7-49
Total..	13,650	20,400	20,400	19,800	

OBJECTIVES AND STATUS:

Materials Processing in Space (MPS) emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Its goal is to test and demonstrate the capabilities of the space environment for materials processing and provide opportunities for independently funded users to exploit space flight for processing activities related to their own needs. As these development, test, and demonstration efforts proceed, the technology will be transferred, as appropriate, to non-NASA users for their use.

Activities in FY 1980 are planned to implement the recommendations of the National Research Council's recent study of "Scientific and Technological Aspects of Materials Processing in Space" (STAMPS), which recommended increased emphasis on ground-based research in several basic areas: closer ties with the scientific community in generating new projects and reviewing progress; and a policy of transferring sponsorship of space activity in materials science and technology to private and non-NASA public organizations as soon as adequately demonstrated techniques become available. In response to the STAMPS recommendations, NASA plans to increase the level of its ground-based research effort, to carry on a continuing program of interface activities with commercial interests, and to confine new flight project initiatives to areas where needs have been documented by prior research.

During FY 1980, the Space Processing Applications Rocket (SPAR) project will conclude its sounding rocket flight operations with two launches and will complete development of the Materials Experiment Assembly (MEA), a system of interface hardware that will enable SPAR payload apparatus to be used in the Shuttle payload bay, thereby prolonging the useful life of the SPAR hardware. The MEA capability may be used to complete some SPAR investigations that can benefit from the Shuttle's longer flight duration.

Fourteen principal investigators have been selected to date to perform materials experiments on the Space Transportation System. They are currently at work on their preparatory ground-based research, in concert with the contractor (TRW) selected in 1978 to develop major equipment items and perform integration tasks. Design of the first group of MPS payload equipment to be built specifically for STS missions will be completed by the end of FY 1980. Correspondingly, the principal investigators in the experiment program for which the equipment is being developed will finalize their plans for experiment implementation.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space Processing Applications Rocket (SPAR) Project...	3,900	3,600	3,600	2,100

OBJECTIVES AND STATUS:

The objective of the SPAR project is to perform applications materials processing flight experiments and related ground-based research on applications of weightlessness to materials processing, in areas where the five minutes of weightlessness available in sounding rocket flights can be useful. The project comprises a group of 26 investigations in materials science and technology, competitively selected from among the responses to three Announcements of Opportunity in 1974-77. Each SPAR payload is configured to meet the requirements of a specific group of investigators whose experiments are ready to fly, and carries from three to five separate experiments. Most investigations in the project require more than one flight to accomplish their objectives.

SPAR rocket flight operations are planned to continue through 1980. The work already accomplished has operationally demonstrated several capable items of new equipment, including apparatus for rapid directional solidification and both electromagnetically and acoustically-suspended containerless processing. It has been found that some of the more sophisticated rocket payload equipment can be useful for experiments on the the Space Transportation System (STS); a set of interface hardware collectively known as the Materials Experiment Assembly (MEA) is being developed by the SPAR project to permit use of this type of apparatus on Shuttle missions. In general, use of the MEA on STS missions will be included in the Shuttle/Spacelab experiment program, although some of the SPAR investigations may be completed on STS flights.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, it is planned to fly two rocket flights with three to five experiments per flight, supported by appropriate preparatory research and post-flight analysis by the principal investigators. In addition, fabrication and checkout activities will be completed for the MEA, leading to its availability for flight by the end of the fiscal year.

Applied Research and Data Analysis (Materials Processing)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Ground-based investigations, analysis, and studies...	4,350	4,400	4,400	6,900

OBJECTIVES AND STATUS:

The Applied Research and Data Analysis (AR&DA) activity in the Material Processing in Space program is structured to emphasize ground-based research in subject areas from which space investigations with applications potential are expected to develop. In addition, the AR&DA program supports technology development for future ground and space capabilities, equipment definition studies responding to identified space experiment needs, and commercialization activities looking toward space activity by private industry.

Current activities are concentrating on science and technology work on infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, containerless processing, heat pipe technology and space vacuum utilization. The commercialization effort includes studies of institutional, legal and economic issues; information activities directed toward industry; and discussions with companies which express interest in undertaking joint space endeavors with NASA. Since FY 1978, most of the activities have been initiated in response to proposals from the scientific community, and this approach will be continued in FY 1980.

BASIS OF FY 1980 ESTIMATES:

In accordance with recommendations made in the National Research Council's study of "Scientific and Technological Applications of Materials Processing in Space," an increased level of effort is planned in ground-based research and development to provide a basis for thoroughly prepared, scientifically justified space flight investigations in the future. With augmented AR&DA funds, MPS will be able to accept an increased number of meritorious research proposals from the scientific community while maintaining continuity in the emphasis areas initiated in FY 1978 and 1979. In addition, critical technology development work will be performed in support of more mature investigation areas, to ensure that the required payload capabilities can be provided when flight experiments are undertaken in these areas.

Shuttle/Spacelab Payload Development (Materials Processing)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Payload development	5,400	12,400	12,400	10,800

OBJECTIVES AND STATUS:

The Space Processing Shuttle Pay oads project includes the design and development of a basic set of payload equipment for space experiments on materials and processes, and provisions for conducting an initial set of experiments with this equipment on Space Transportation System (STS) flights through 1982. Fourteen investigations have been selected for the initial experiment program, covering topics in crystal growth, fluid flow effects, physical metallurgy, spec alized composite materials, and advanced glass technology. All of the equipment will be designed for repeated use and a long service lifetime, so that other experimenters can make use of it in later years.

All of the principal investigators selected for flight are now under contract and performing their preparatory ground-based research; in addition, an investigators' working group has been formed and is overseeing the equipment design and the definition of mission requirements. TRW has been engaged as the prime contractor to build two major payload facilities, the Fluid Experiments System (FES) and the Solidification Experiments System (SES), as well as to integrate the entire payload. A third multiuser facility, the Acoustic Containerless Processing Module (ACPM) is being designed by the Jet Propulsion Laboratory. Three of the investigators will use equipments peculiar to their experiments which are being developed under separate contracts.

BASIS OF FY 1980 ESTIMATE:

Design work will be completed on all payload apparatus in FY 1980, leading to critical design reviews and initiation of manufacturing in April for the FES and in July for the SES and the ACPM. At that time, the principal investigators will freeze their experiment implementation requirements for the first flights of the apparatus and begin work on preparation of flight samples and refinement of process parameters. A Ground Control Experiments Laboratory containing apparatus identical to the flight equipment in all scientifically significant respects will be set up in August-November for ground-based simulation and comparison experiments by the investigators. This activity will proceed at a level of effort leading to delivery of flight articles in 1981 and first flights of the apparatus in 1982.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SPACE COMMUNICATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Search and rescue mission	5,600	8,000	8,000	5,000	7-51
Shuttle/Spacelab payload development	1,000	1,200	1,200	1,400	7-52
Technical consultation and support studies	3,100	3,100	3,100	3,000	7-53
Applied research and data analysis	5,650	3,700	3,900	6,200	7-54
Follow-on data analysis and operations	3,800	4,500	4,500	3,800	7-56
Total	19,150	20,500	20,700	19,400	

OBJECTIVES AND STATUS:

The objective is to provide for efficient and effective use of limited geosynchronous orbit and radio spectrum resources while promoting United States leadership by support of technology development in satellite communications. The communications research and development effort reflects the recent Presidential space policy stating that United States leadership in communications satellite systems will be supported by NASA and that selected technological opportunities to provide better frequency and orbit utilization and other longer-term opportunities will be pursued. The effort, incorporating the advice of the communications industry, will complement private sector research and development. In FY 1980, the communications program will focus on the development of a strong technology base--particularly in the development of multibeam antennas and on-board switching techniques--from which future plans for developing new capabilities and flight test programs can grow.

FY 1980 funds will support the continued development of the Adaptive Multibeam Phased Array (AMPA) antenna. This antenna will, on command, conduct experiments in forming, shaping, and pointing its transmit and receive beams quickly to ground users in different locations, while avoiding interference.

The experimental Search and Rescue satellite program, which will use satellites to aid in the detection and location of distress beacons carried by ships and aircraft, will continue in FY 1980. During FY 1979, we will modify the appropriate NOAA operational meteorological spacecraft (NOAA-E, -F, -G) to accept Canadian and French equipment, develop spacecraft antennas, build a ground station to accept satellite data and develop a flight test program. This work is done in conjunction with the Departments of Transportation and Defense and with France and Canada.

FY 1980 funds will support the continued operations of ATS-1 and ATS-3, while providing for the orderly phaseout of the ATS-6 and CTS public service user experiments and demonstration. These funds will also provide for the transition of Federal Public Service Communications activity from NASA to the National Telecommunications and Information Administration within the Department of Commerce. During FY 1980, we will work with the National Telecommunications and Information Administration and its Interagency Committee on Satellite Telecommunications Applications (ICSTA), representing 18 Federal agencies, to undertake technology development which will meet the needs of a growing national satellite communications community.

Search and Rescue Mission

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Search and rescue mission	5,600	8,000	a,000	5,000
Atlas (expendable launch vehicles program)	(---)	(---)	(---)	(2,000)

OBJECTIVES AND STATUS:

The objective of the Search and Rescue Mission is to demonstrate the feasibility of using satellites to provide a significant improvement in the capability for search and rescue forces to detect and locate distress signals from general aviation aircraft and certain marine vessels during emergencies. Systems studies have shown that satellites flying at an 850 kilometer altitude can detect the emergency beacons presently carried by aircraft and ships. Preliminary calculations indicate that the satellite can fix the position of these beacons to an accuracy of about 15-20 kilometers, and could position a proposed new beacon, with its stronger signal, to about 5 kilometers. This will permit rescue forces to arrive at the accident scene more quickly than is presently possible.

This interagency program is being conducted jointly with Canada and France; discussions with the Soviet Union are also underway. The U.S. will provide the spacecraft, launch vehicle, and the U.S. ground stations; the Canadians will provide the space telecommunications equipment and ground station in their country; and France will provide an onboard processor and receiver. In addition to NASA, the Departments of Defense, Transportation, and Commerce (NOM) are expected to participate in the program test and evaluation phase.

Presently, we are designing the modifications which will enable the NOM-E spacecraft to accept search and rescue instruments; the specifications for a new improved 406 MHz Emergency Locator Transmitter are being prepared; and required additions to existing NOAA ground stations are underway.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will support the modification of the NOM-E, -F, and -G spacecraft, enabling them to accept a Canadian-provided transponder and a French-provided on-board processor. FY 1980 efforts will also focus on developing "receive and transmit" spacecraft antennas and continuing the development of the advanced emergency beacon to conduct search and rescue experiments.

Shuttle/Spacelab Payload Development (Space Communications)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Payload development	1,000	1,200	1,200	1,400

OBJECTIVES AND STATUS:

The objective is to develop promising communications payloads that will capitalize on the unique capabilities of the Space Shuttle and Spacelab missions beginning in the early 1980's.

In FY 1979, development work will continue on an Adaptive Multibeam Phased Array (AMPA), antenna that will provide a significant improvement in the radiated power that can be received by ground-based communications systems. This type of spaceborne antenna has direct applications to education, health care delivery and postal services, and for service to small mobile terminals that might be used on trucks and autos, and data collection platforms.

Airborne Instruments Laboratory, on contract with the Goddard Space Flight Center, has begun the design of the AMPA antenna that, on command, can form, shape, and point its transmit and receive beams quickly to small ground areas in different geographic locations, while avoiding interference. AMPA will be ready for flight in 1982.

BASIS OF FY 1980 BUDGET ESTIMATE:

FY 1980 funding will support the continued development of the 32-element phased array antenna to operate at 1.6 GHz. FY 1980 activities will include development, manufacture, assembly and test of the instrument at the system level, in preparation for an early Spacelab mission. This will include the development of needed ground equipment and experimental platform units.

Technical Consultation and Support Studies

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Technical Consultation and Support Studies................	3,100	3,100	3,100	3,000

OBJECTIVES AND STATUS:

The objective of this program is to provide technical consultation, special studies, and experiments on frequency and orbit utilization for NASA and other U.S. Government agencies. Studies and experiments being performed help provide technical and regulatory frameworks to allow growth of existing satellite services and provide for the inclusion of new satellite applications. The effort is grouped into three main categories: orbit and spectrum utilization; satellite systems support; and communciations satellite application system studies.

Orbit and spectrum utilization includes the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effects of propagation phenomena and man-made noise on performance, design, and orbit and spectrum utilization of space telecommunication systems.

Satellite systems support includes design and flight readiness reviews and technical assessments on Intelsat and Domsat systems for the Federal Communications Commission (FCC) and special studies on high priority FCC and NASA program office requests.

Communications satellite application system studies are structured to meet, primarily, statutory and regulatory requirements and to ensure compatibility of NASA flight programs with other space and terrestrial services.

These studies and experiments supported U.S. preparation and NASA participation in the October 1978 Special Preparatory Meeting leading to the 1979 World Administrative Radio Conference.

BASIS FOR FY 1980 ESTIMATE:

In FY 1980, emphasis will be placed upon the completion of our preparation and participation in the 1979 World Administrative Radio Conference (GWARC) and an assessment of its results and implications for U.S. telecommunciations. Studies will be expanded in support of the 1983 Region 2 (Western Hemisphere) Conference on Broadcast Satellites.

FY 1980 studies and experiments will be undertaken in the areas of active and passive microwave sensors essential to resource and environmental observations; broadcast and mobile satellite services; emergency and disaster communications; energy transmission from space; and techniques, models, and strategies for improving the use of the radio frequency spectrum and the geostationary orbit.

Applied Research and Data Analysis (Space Communications)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced communications research....................	4,300	2,300	2,300	4,200
Wideband 30/20 GHz definition......................	---	---	---	1,200
Applications pilot test..........................	1,100	1,100	1,300	800
Development of advanced flight experiments.........	250	300	300	---
Total..	5,650	3,700	3,900	6,200

OBJECTIVES AND STATUS:

The Applied Research and Data Analysis (AR&DA) activities consist of system studies, development of technology for proof-of-concept flight programs, and experiments which provide new technology and technique concepts to aid private industry in offering new, improved and affordable communcations services. Specifically, NASA will concentrate on the development of multi-beam space antennas and on-board switching techniques, as well as associated system technologies.

Technology development is directed toward the efficient and effective use of the limited spectrum and orbit resources. This objective has been supported through the development of bandwidth compression techniques and new "frequency re-use" space antenna methods. Data collection technology has also been developed which lowers the cost and improves the efficiency of data collection platforms.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The Applications Pilot Test Program budget was increased to facilitate increased personnel training capability at the Denver Uplink Terminal in order to effectively complete technology transfer efforts prior to the end of public service user experiments on ATS-6.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will support two essential technology efforts in Advanced Communications Research to be undertaken in conjunction with the Office of Aeronautics and Space Technology (OAST): systems development and component development. The Office of Space and Terrestrial Applications (OSTA) will address the complex systems aspects of commercial satellite communications in several ways, including development of concepts for major subsequent decisions regarding traffic type, size, costs, and schedules. The associated systems hardware development concentrates on the performance of multi-beam antennas and on-board switching. The OAST will undertake the development of specific, identified, hardware components to include multi-beam antenna switches, efficient power amplifiers, and low-noise mixers. Some propagation modeling and ground terminal technology development at 30/20 GHz will also be undertaken.

In addition, funds are requested for a "Wideband" project definition activity to provide systems analysis and project definition which will enable the use of the 30/20 GHz band, allowing a proof-of-concept test for demonstrations of capacity and understanding of propagation effects.

In the Applications Pilot Test program, NASA will continue to support the public service communications project with the Public Service Satellite Consortium for the conduct of satellite communications experiments. In addition, at the request of the U.S. Coast Guard, we are conducting a demonstration to aid in locating vessels in the 200-nm Coastal Zone; in this demonstration, participating ships will relay their LORAN-C derived navigation data through an existing geostationary satellite to a ground-based computation center.

Follow-on Data Analysis and Operations

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Follow-on Data Analysis and Operations......................	3,800	4,500	4,500	3,800

OBJECTIVES AND STATUS:

The objective is to provide for a wide range of user experiments and demonstrations in the application of satellite communications. Experiments with the ATS-6 and CTS spacecraft have generated a great deal of interest, both nationally and internationally, in satellite telecommunciations. Nearly 400 communications experiments using ATS-6 and CTS have been successfully conducted during the extended lifetimes of these satellites to provide user experience for making decisions regarding their communications functions. NASA's stimulus in encouraging use of these unique facilities is now leading to use of commercial satellites which can better meet the needs for flexibility and continuity of services. NASA is supporting this transition. Complete reports on experiment results will be prepared for use by many interested groups that did not directly participate.

BASIS FOR FY 1980 BUDGET ESTIMATE:

FY 1980 funding will provide for continued support of the ATS-1 and -3 experimentation and support activities. Public service user experiments on CTS will be completed by June 30, 1979, and experiments on ATS-6 by September 30, 1979. FY 1980 will begin the phasedown years, during which results of 400 experiments performed since 1969 will be appropriately compiled so that the results may be of value to future activities following the ATS-6 and CTS experiments. These final reports will also support the National Telecommunications and Information Administration's efforts to transfer the public service satellite communications community to commercial satellites and services. A continuing activity in this support will be the Systems Architecture Study in which a thorough and careful investigation of all practical commercial communications links for the Public Service user is made.

TECHNOLOGY
UTILIZATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET **SUMMARY**

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
Technology dissemination	3,600	3,715	3,600	3,800	8-3
Technology applications	4,100	4,110	4,100	4,400	8-4
Program evaluation and support	1,400	1,275	1,400	1,500	8-4
Civil systems*	(2,100)	(1,800)	(1,800)	2,400	8-4
Total	9,100	9,100	9,100	12,100	

Distribution of Program Amount by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Johnson Space Center	100	250	160	200
Kennedy Space Center	195	100	90	150
Marshall Space Flight Center	635	600	482	500
National Space Technology Laboratories	--	100	--	50
Goddard Space Flight Center	680	550	857	900
Jet Propulsion Laboratory	539	500	477	1,700
Wallops Flight Center	10	100	4	200
Ames Research Center	857	800	595	1,000
Dryden Plight Research Center	67	100	54	60
Langley Research Center	868	750	938	1,000
Lewis Research Center	256	200	328	400
Headquarters	4,893	5,050	5,115	5,940
Total	9,100	9,100	9,100	12,100

*Beginning with FY 1980, this effort is to be funded in Technology Utilization instead of Space Applications.

PROGRAM OBJECTIVES AND JUSTIFICATION

Technology Utilization Program objectives encompass the transfer of new knowledge and innovative technology resulting from NASA aeronautical and space R&D programs for application and use in industry, medicine and important public sector areas such as transportation, environment, urban development and public safety. Specific program objectives are:

(1) To expedite and facilitate the application and use of new technology, shortening the time between generation of advanced technologies and their use in the economy;

(2) To encourage multiple secondary uses of NASA technology in industry, education and government where there is a wide spectrum of technological problems and needs;

(3) To understand more fully the technology transfer process and its impact on the economy, and to manage and optimize the process in a systematic way; and

(4) To develop applications of NASA's aerospace expertise - its technology, technologists and unique facilities - to priority non-space needs of the nation.

Aerospace technology is transferred to the public and private sectors of the nation's economy through a variety of established mechanisms developed and managed under the NASA Technology Utilization Program. These mechanisms or project areas include: publications and announcements, Industrial Applications Centers, the Computer Software Management and Information Center (COSMIC), State Technology Applications Centers, applications teams/applications engineering projects, and civil systems projects.

OBJECTIVES AND STATUS:

During the past year, NASA's Tech Brief journal for announcing available technology continued to generate more interest and awareness in the industrial community than at any time previously. The rapid growth and expansion of the Tech Brief mailing list (over 1,300 new addresses per month) and over 60,000 journal-related industrial inquiries received by NASA during 1978, are positive reflections of this sustained interest.

NASA Industrial Applications Centers (IACs) and the Computer Software Management and Information Center continued to increase in number of industrial clientsand income duringthepast year. IAC industrial income for 1978 was $2.2 million compared to $1.8 million for the previous year. COSMIC income was up by *40%* when compared with 1977. In addition, a cooperative project with the Small Business Administration to provide IAC services to over 700 small businesses in southern California and in the northeast has been highly successful, and similar efforts patterned after these experiments are planned in other regions of the U.S. in FY 1979 and FY 1980.

Over 70 applications engineering projects for adapting existing aerospace technology to defined needs in the public sector were active last year. These projects are jointly funded by NASA and user agencies such as DOT, HEW, EPA, and the Department of Commerce. Among the many projects are the portable firefighting module developed for the U.S. Coast Guard, a highly reliable water quality monitor for EPA, and a human tissue stimulator being developed in conjunction with Johns Hopkins University Medical Center (Pain Center) and the National Institutes of Health. Increasing attention will be devoted to the problems of the handicapped, with special emphasis placed on assisting the aged and developing aids for rehabilitation.

Transfer of the Civil Systems Program to Technology Utilization consolidates all NASA Terrestrial Applications engineering projects for public and private sector organizations. Current projects include the Advanced Ocean Technology Development Platform (AOTDP) for use in evaluating and generating new deep ocean instrumentation and sensors; environmental sensors and systems to detect and analyze air and water pollutants; applications of aerial thermography for energy conservation; and assistance to the U.S. Coast Guard and NOAA in implementing project ICEWARN, which utilizes side-looking airborne radar technology to monitor ice formations on the Great Lakes shipping channels.

Documented evidence of technology transfer (i.e., the annual "Spinoff" report) is continually recorded, evaluated and disseminated to industry and the general public as a means of creating widespread awareness of program activities and available NASA technology transfer services. Efforts continue on methods and procedures to increase the efficiency and effectiveness of all programs.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 adjustment between technology dissemination and program evaluation and support results from increased changes for data bank computer support for information retrieval activities at NASA's Scientific and Technical Information Facility.

BASIS OF FY 1980 ESTIMATE:

Technology Dissemination

In FY 1980, NASA plans to improve service to users of TU publications (e.g., NASA Tech Briefs) by providing field center support for inquiry handling and technical support package preparation; permitting NASA industrial Applications Centers and COSMIC to develop new user marketing strategies; expanding market penetration of selected industrial segments (e.g., small manufacturing firms); and providing additional geographical coverage of established IACs with remote sales personnel located in highly industrialized urban areas. IAC coordinator activities at NASA field centers will be continued to facilitate access to on-going NASA research and development programs for industrial users. The two State Technology Applications Centers (STACs) in Florida and Kentucky will broaden their experimental methods for transferring aerospace technology to state and local governments.

Technology Applications

In FY 1980, NASA's existing applications teams will place additional emphasis on transportation and public safety activities to focus on priority problems encountered in state and local government (e.g., Dade County Mass Transit System development project, fire safety, and law enforcement). Efforts will also be continued to respond to public sector application project opportunities in agriculture, mine safety, transportation, urban construction, medical diagnostic systems, and rehabilitation for the handicapped.

Program Evaluation and Support

In FY 1980, NASA plans to continue transfer research and impact studies to evaluate and quantify benefits resulting from TU program transfer mechanisms (e.g., cost-benefit evaluation of application teams). Economic analysis studies of NASA benefits resulting from direct as well as indirect secondary uses of NASA research and development will continue.

Civil Systems

In FY 1980, NASA plans to focus its institutional expertise on specific non-space problems in the areas of environmental monitoring and control, agricultural productivity, and deep ocean survey and exploration. In addition, the program will allow for a certain degree of flexibility in the selection of new projects that explore innovative applications of aerospace-derived technology to other non-aerospace-oriented disciplines. Specific projects include the extension of our atuomated water monitoring system to measure 'contaminants in potable water and monitoring the quality of natural water bodies. Completion of the field testing of the Agro-Environmental Monitoring System is expected in FY 1980 and demonstration of the applicability of advanced radar tracking techniques to insect monitoring will be accomplished. In the area of ocean technology, a definition study will be accomplished for a sea bed lander as part of the Office of Naval Research/Woods Hole Oceanographic Institute High Energy Benthic Boundary Layer Experiment (HEBBLE). This project will investigate a broad range of physical phenomena accompanying high velocity currents at the sea floor/ocean interface at depths of 3000 to 6000 meters.

AERONAUTICS AND
SPACE TECHNOLOGY
PROGRAMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

Programs	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aeronautical research and technology	228,000	264,100	264,100	300,300
Space research and technology	97,700	108,300	107,300	116,400
Energy technology	7,500	3,000	5,000	3,000
Total	333.200	375.400	376.400	419.700

AERONAUTICAL RESEARCH AND TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Research and technology base	97.805	109.200	109.200	117.500	9-4
System studies	3.000	3.000	3.000	3.200	9-18
Systems technology programs	75.765	85.645	85.645	106.100	9-20
Experimental programs	51,430	66.255	66.255	73.500	9-32
Total	228.000	264.100	264.100	300.300	
Distribution of Program Amount by Installation:					
Johnson Space Center	700	1.100	1.245	700	
Marshall Space Flight Center	756	1.100	958	900	
Jet Propulsion Laboratory	1.275	1.200	1.310	1,100	
Wallops Flight Center	953	500	619	700	
Ames Research Center	41.100	49.600	49.312	51.900	
Dryden Flight Research Center	14.423	9.100	9.047	13.400	
Langley Research Center	94.862	93.500	93.961	115.300	
Lewis Research Center	71.050	104.900	104.452	113.000	
Headquarters	2.881	3.100	3.196	3.300	
Total	228.000	264,100	264.100	300.300	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Aeronautics program are to advance aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft.

The FY 1980 program supports these objectives by stressing the technology areas judged to be the most critical by in-house and external assessments, industry, advisory groups, and other users of technology within and outside the Federal Government. Emphasis will be placed on improving aircraft energy efficiency and performance; reducing noise and pollution; and improving safety and terminal area operations; and advancing long-haul and short-haul air transportation concepts.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Funding adjustments between elements within the Aeronautical Research and Technology program have been made in response to changing program requirements which have developed since the budget estimates. Explanations of these funding changes are provided under each individual program involved.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 activities are designed to maintain a strong Research and Technology Base position in the technology disciplines of aerodynamics, propulsion, avionics and flight controls, human-vehicle interaction, materials and structures. The strength of this generic research and technology base is essential to enhance the growth of new, improved aeronautical products. The program also provides focused technology development activities for each of the major classes of aeronautical vehicles, i.e., conventional takeoff and landing (CTOL) aircraft, rotorcraft, general aviation aircraft, vertical/short takeoff and landing (V/STOL) aircraft, supersonic cruise aircraft, and high performance aircraft.

In the area of CTOL technology, progress in the aircraft energy efficiency efforts will continue toward the goal of providing, in the 1980's, the technology advances leading to a major reduction in aircraft fuel requirements. The design, fabrication and testing of individual components to validate the technology for use in next-generation, high-bypass turbofan engines will continue in the Energy Efficient Engine program. In the Engine Component Improvement program, the development of components with improved performance retention characteristics will be completed. In the Energy Efficient Transport program, work will continue with the major airframe contractors to develop and evaluate advanced aerodynamic and active control technologies for derivative and new subsonic transport aircraft. Included are wind tunnel tests of advanced winglet concepts. In the Laminar Flow Control (LFC) program, wind tunnel models will be evaluated, and the design of a full-scale LFC wing will be initiated. The safety effort will be continued with emphasis on human-vehicle interrelationships. The Fire Resistant Materials Engineering (FIREMEN) activity will be completed, providing technology for materials with improved fire resistance and low toxicity properties.

Rotorcraft technology activities will continue to address rotor aerodynamics, structures, avionics, flight dynamics, terminal operations, engines and drive systems, and rotor system design. Checkout flight tests of the new Rotor Systems Research Aircraft (RSRA) vehicles will be completed, and modifications will begin on existing helicopter rotors for flight test on the RSRA. An advancing blade concept (ABC) helicopter will be tested in the Ames Research Center's 40 by 80-foot wind tunnel to correlate wind tunnel data with flight test data.

In the area of general aviation, the development of technology for increased aerodynamic efficiency, crash-worthiness, and reduced noise and emissions will continue, and the activity to develop the technology for advanced avionics systems with reduced complexity will be completed.

Vertical takeoff and landing technology efforts will emphasize broad-based technology for future military and civil aircraft applications, Short takeoff and landing (STOL) technology efforts will include ground-based simulator and flight investigations to develop design criteria applicable to quiet short-haul transports. The Quiet Short-Haul Research Aircraft (QSRA) will begin the flight experiments program to determine aero/acoustic characteristics, handling qualities, operating efficiency and certification criteria.

In supersonic cruise research, emphasis will be placed on the interactions between the airframe and propulsion system, long-life structural tests, wind tunnel evaluations, and the demonstration of advanced propulsion components for fuel-efficient variable-cycle engines with low noise and emissions.

In the area of high performance aircraft, efforts will continue on configuration aerodynamics, aeromechanical instability characteristics of advanced turbojet and turbofan engines, and two-dimensional exhaust nozzles. Flight testing of Highly Maneuverable Aircraft Technology (HiMAT) concepts will be continued, employing subscale remotely piloted vehicles.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
Materials research and technology	6,300	7,300	7,300	7,500	9-4
Structures research and technology	8,740	11,500	10,600	11,700	9-5
Propulsion environmental impact minimization research and technology	9,725	10,300	10,300	10,500	9-7
Propulsion components research and technology	11,475	12,500	12,500	13,000	9-8
Air-breathing engine systems research and technology	8,670	8,800	8,800	8,900	9-9
Avionics and flight control research and technology	3,985	5,200	5,200	6,200	9-11
Aircraft operations and safety research and technology	4,810	5,500	5,500	6,600	9-12
Fluid and flight dynamics research and technology	14,495	16,500	16,500	20,700	9-13
Low-speed vehicle aerodynamics and flight dynamics research and technology	12,700	13,000	13,000	12,600	9-15
High-speed vehicle aerodynamics and flight dynamics research and technology	11,905	13,000	13,900	14,100	9-16
Human-vehicle research and technology	5,000	5,600	5,600	5,700	9-17
Total	97,805	109.200	109.200	117.500	

Materials Research and Technology	6,300	7,300	7,300	7,500

OBJECTIVES AND STATUS:

The objective of the Materials Research and Technology program is to develop advanced metal, ceramic, polymer and composite materials needed to improve the performance, safety, longevity and economy of U.S. aircraft. Areas of emphasis include high temperature engine materials, life prediction procedures, and lightweight structural materials having high specific strength and stiffness.

Improvements have been made in the properties of several high temperature metal alloys, ceramics and composites that promise increased performance and efficiency in gas turbines and aircraft structures. Advances also have been made in the capability to predict the life of composites and metals which will improve the reliability of aerospace systems.

BASIS OF FY 1980 ESTIMATE:

Research on high temperature materials will continue to emphasize improving the strength and service life of gas turbine materials. During FY 1980, materials processing and design technology will be developed for an oxide dispersion alloy and a tungsten fiber reinforced superalloy which may have potential for hollow turbine blade applications. A manufacturing method will be developed to produce a low cost disk alloy having improved mechanical properties. Basic research on the mechanisms of corrosion and oxidation of turbine alloys will continue. Ceramic materials will continue to be developed, with emphasis on improving high temperature strength and impact resistance.

Research will continue on the fatigue fracture and behavior of metallic and composite materials in both benign and aggressive environments. Similar research will begin on ceramic materials. Research will be accelerated to extend existing life prediction techniques and analyses with emphasis on applying the method of strainrange partitioning to predicting the life of engine components. Studies will continue on the mechanism of hydrogen embrittlement of steels with the objective of developing hydrogen-resistant alloys. To predict service durability of composites, a damage growth law will be developed.

Research on composites will continue to be emphasized in the development of stiff, lightweight, strong structural materials. In FY 1980, research will continue to synthesize monomer reactants for use in polyimides, a high temperature class of resins. These resins will also be studied for use in low cost fabrication processes. At the Langley Research Center, a series of resins will continue to be improved and will be studied for possible application as adhesives. The fabrication and evaluation of boron/aluminum composites for high speed engine blades will continue in FY 1980. Research on large CTOL engine blades will be redirected toward improving impact resistant boron/aluminum technology. A data base will continue to be developed for the combustion characteristics and the thermochemical, thermalphysical and photochemical properties of new and advanced state of the art polymers.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Structures Research and Technology	8,740	11,500	10,600	11,700

OBJECTIVES AND STATUS:

The objective of the Structures Research and Technology program is to provide advanced technology that will result in significant improvements in the performance, safety, durability, and economy of commercial, military, and general aviation aircraft and helicopters. Major emphasis is given to advanced structural concepts for airframes, improved techniques for predicting structural loads and dynamic response, more accurate and efficient design methods for airframes and engines, and concepts for high speed airframe and engine structures.

Composite helicopter components have been developed for flight service evaluation, which will begin in late FY 1979. The performance of an active wing flutter suppression system has been verified in wind tunnel tests in preparation for drone flight testing in FY 1979, and the effectiveness of a wing/store flutter suppression system has been verified in wind tunnel tests. Energy-absorbing seat and restraint systems for light aircraft have been developed and evaluated in simulated crash conditions,

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $900 thousand reflects a realignment of funds within the Research and Technology Base to provide increased wind tunnel support of high priority research in the high speed vehicle aerodynamics and flight dynamics area.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds provide for continued progress in investigating applications of composites in fixed-wing aircraft and rotorcraft. Emphasis will be placed on fuselage primary structures and the development of methods for evaluating and increasing the durability and damage tolerance of composite secondary components on commercial and military aircraft.

As a result of the in-house assessment, an increased emphasis will focus on the areas of structural dynamics and aeroeleasticity. The emphasis in FY 1980 will be on verifying the capability of active flutter suppression systems to increase flutter boundry speeds by 20 percent, developing methods for accurately predicting acoustic loads and noise transmission through structures and improving analytical and test methods for predicting unsteady transonic aerodynamic loads for wings and control surfaces.

Development of advanced design methods in FY 1980 will concentrate on analysis capability for predicting aircraft response to crash impacts, multidisciplinary methods for design of control configured aircraft, exploitation of advances in computer-aided design hardware, and improved understanding of structural failure mechanisms. Efforts will continue to improve crash safety of general aviation aircraft and emphasis on crashworthiness of commercial transport aircraft will be increased.

The efforts on turbine engine structures will be increased in FY 1980. Emphasis will be given to defining and developing the most promising applications of composites in advanced engines and to developing improved design and analysis methods needed to provide the technology for more reliable, lightweight engine structures, including hot section components. This effort will include such activities as an analysis to predict engine rotor transient dynamic response during loss of a fan blade.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propul ion Environment 1 Impact Minimization Re earch and Technology...	9,725	10,300	10,300	10,500

OBJECTIVES AND STATUS:

The objective of the Propulsion Environmental Impact Minimization Research and Technology program is to reduce noise and exhaust pollution from aircraft propulsion systems to environmentally acceptable levels in ways that are economically and operationally sound. The technology advances achieved will aid the aviation industry in developing new designs and will provide technical information to the Government for use in establishing noise and exhaust emission regulations.

In the area of forward velocity effects on propulsion system noise, the rotating fan blades of a Pratt & Whitney JT15-D engine have been modified and instrumented in preparation for a series of tests to correlate static and flight test noise data. The results of tests in the clean combustor program indicate that emission levels that compare favorably with proposed FY 1979 Environmental Protection Agency standards were obtained.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, research will be conducted to determine more accurately the phenomena of large scale exhaust motion in the generation of noise in jets, turbulence ingestion on rotating machinery noise and propeller noises. The understanding of these phenomena will support development of advanced noise suppression techniques. Investigations will be performed to determine atmospheric absorption characteristics of propulsion noise. Advanced analytical techniques will be developed for updating the aircraft noise prediction computer program. Experimental data will be gathered to validate the predictive capabilities of the program. In FY 1980, continued emphasis will be given to determining the effects of aircraft forward speed on propulsion generated noise. The OV-1 airplane is being modified to accommodate the JT15-D engine in order to conduct flight tests for noise measurements. These tests will provide the understanding needed to extrapolate the static data of advanced concepts to flight conditions.

Pollution reduction research will address the problems of aircraft piston engine emissions, as well as aircraft gas turbine emissions. The work is conducted at a fundamental level, seeking answers to the mechanism of pollutant formation and its control. In the gas turbine area, FY 1980 activities will continue on development of analytical pollutant formation models, and on advancing fundamental technology of combustion to support design of very low emission combustors for future generations of aircraft gas turbines. Aircraft piston engine emissions reduction technology efforts in N 1980 will develop analytical methods of predicting emissions and will identify promising piston engine concepts, based on capability to operate with low emissions and acceptable fuel efficiencies.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Propulsion Components Research and Technology	11,475	12,500	12,500	13,000

OBJECTIVES AND STATUS:

The objectives of the Propulsion Components Research and Technology program are to increase air-breathing aircraft engine efficiency; to improve engine operations over a wide range of engine flow conditions; to reduce fuel consumption and weight, and to improve the reliability and durability of engine components. The efforts include research on gas path components, as well as mechanical components, fuels and propellers. This activity provides the advanced technology that ultimately supports improved, more cost effective and energy efficient propulsion systems for all applications--ranging from small, general aviation private aircraft to commercial transports and helicopters, as well as military aircraft of all types.

In FY 1979, the Propulsion Components Research and Technology effort continues emphasis on computational techniques. Added effort is also being given to solving problems unique to small turbine engine components.

BASIS OF N 1980 ESTIMATE:

In FY 1980, research on inlets and nozzles will continue to concentrate on development of analytical techniques which will accurately predict localized internal flow phenomena, including shock-wave/boundary layer interactions in the presence of boundary layer bleed. Detailed small scale experimental investigations will verify these fundamental internal flow processes.

Fan, compressor and turbine research in FY 1980 will reflect the increasing emphasis on utilization of computational techniques as a design tool. In addition, more effort will be devoted to identification and solution of those problems peculiar to small compressors of a size suitable for helicopter or small aircraft propulsion and small turbines, with particular attention to the design of effectively cooled turbines.

Next-generation commercial turbofan engines will operate at cycle pressures and temperatures significantly higher than current models. Combustor research in FY 1980 will continue to concentrate on solving the problems of durability, efficiency, and emissions which are related to the more severe operating cycles of advanced engine designs. Work on problems peculiar to small turbine engine combustors will be accelerated.

Fuels research is based on the premise that future jet engine fuels may require a relaxation of current specifications in order to enhance supplies and hold down costs. Problems associated with relaxed specification fuels are luminosity, soot formation, thermal instability, and fuel freezing. All of these problems will continue to be investigated in FY 1980, in coordination with related work on combustors and emissions.

Mechanical components research activity in FY 1980 will continue on evolutionary improvements in the technology of gearing, seals, bearings, lubricants and power transmission shafting. Emphasis will be placed on obtaining a good understanding of the basics of mechanical wear phenomena. This understanding is needed to improve the durability and performance retention of turbomachinery.

Engine improvements require corresponding improvements in measuring techniques. In 1980, this highly sophisticated area will continue to concentrate on high pressure and high temperature measurement techniques, clearance sensing between rotating and stationary machinery, vibration and stress measurements, and gas path flow visualization and measurements.

Low speed aircraft propeller technology, recently revived after many years of dormancy, applies modern aerodynamic, material and structural theory to propeller design to achieve lighter weight, quieter and more efficient small aircraft propellers. In FY 1980, research will be well underway on advanced propeller blade aerodynamic designs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Air-Breathing Engine Systems Research and Technology......	8,670	8,800	8,800	8,900

OBJECTIVES AND STATUS:

The objective of the Air-Breathing Engine Systems Research and Technology program is to develop the technology for reducing both the costs and time required for new engine development programs through improved engine systems design and analysis techniques, and the assessment of potential new system concepts.

Investigations in areas such as the effects of distortion on system stability and performance of a high bypass turbofan engine and improvements in stability and combustion efficiency of swirl augmentor concepts will be completed in FY 1979. Calibration of an advanced pressure distortion generator will be completed prior to initial operations with a turbojet engine system. An investigation of thrust transfer performance, using variable inlet guide vanes installed ahead of the fixed pitch fan of a high bypass turbofan engine, will also be completed. An evaluation of Short Take-off and Landing propulsion and airframe system noise will be initiated, utilizing the engines from the Quiet, Clean, Short Haul Experimental Engine activity in combination with typical powered-lift, wing flap configurations.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, research on propulsion control systems will verify the methodology needed to simulate overall performance of advanced aircraft/inlet/turbofan engine systems, and investigate advanced control hardware concepts such as sensors and sensor failure accommodation, signal transmission and severe environment electronics, fault-tolerant propulsion controller, and reliable control software.

Experimental and analytical efforts will be continued in FY 1980 to understand and solve the dynamic interaction problems encountered when engine components are combined to form an engine system. Particular emphasis will be placed on the effects of distortion on overall system stability and performance, and an advanced pressure distortion generator will be introduced into the full-scale research program. Investigations peculiar to small engines and helicopter applications will also be initiated utilizing a small turboshaft engine. Aeromechanical instabilities in fan stages will also be investigated in FY 1980.

The Vertical Short Take-off and Landing (V/STOL) related propulsion work will include analytical and experimental studies of the aerodynamics of engine inlets and nozzle deflectors applicable to these propulsion systems. Evaluation of the system noise of the Quiet, Clean Short Haul Experimental engines when mated with typical power lift, wing flap configurations will be completed.

In FY 1980, hypersonic propulsion research will increase the focus on combustion diagnostics and kinetics-related problems. Improved subscale scramjet modules will be evaluated at Mach numbers 4 and 7.

Several alternative propulsion concepts to the piston engine are considered to be potantial candidates for future general aviation aircraft applications. The rotary combustion engine and the lightweight diesel, presently judged to be the most promising candidates beyond an advanced spark ignition piston engine, will receive emphasis in FY 1980. Engine conceptual design studies will be conducted, as well as experimental evaluations of key technology areas. Engine/airframe systems studies will be conducted to evaluate overall performance.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Avionics and Flight Control Research and Technology.......	3,985	5,200	5,200	6,200

OBJECTIVES AND STATUS:

The objective of the Avionics and Flight Control Research and Technology program is to support the development of advanced electronics for applications to both civil and military aviation. Major efforts are directed toward enhancing utility, safety and efficiency, while reducing costs, through innovative approaches in the areas of communication, guidance, navigation, control, and displays.

The results of precursory studies of satellite navigation systems and automatic data link systems support the development of the respective systems. Recent improvements in aeroelastic/control analysis will enable the synthesis of more integrated system designs.

BASIS OF FY 1980 ESTIMATE:

Research in the area of digital operations is conducted to provide technology for the design of precise navigation and guidance systems, and automated digital data links which are cost-effective for civil aviation applications. In FY 1980, candidate navigation systems designs will be studied to establish their relative performance and complexity. These studies and experiments are consistent with the planned implementation of the Department of Defense Global Positioning System in the 1980's.

As a result of the in-house assessment, increased emphasis will be placed on advanced display generation and digital processing technology applied to cockpit display and flight management systems. These improved systems will reduce crew workload, improve safety and enhance aircraft management efficiency. Cockpit display requirements will be determined and incorporated into an experimental design for evaluation.

An integrated design of currently independent control functions promises to enhance the efficiency and economics of future aircraft. In FY 1980, preliminary functional requirements for an integrated control design will be defined and associated mechanization concepts will be outlined.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Aircraft Operations and Aviation Safety Research and Technology	4,810	5,500	5,500	6,600

OBJECTIVES AND STATUS:

The objective of the Aircraft Operations and Aviation Safety Research and Technology program is to provide technology which can be used to solve a wide variety of aeronautical safety and safety-related operational problems.

Considerable progress has been made in the past few years in aircraft fireworthiness technology. As a key example, during FY 1978 large-scale test methodologies were developed which offer improved correlation with real fires. Flashover parameters were also established and, through a wide variety of analytical modeling and testing, a much improved understanding of fire dynamics has been obtained. This knowledge gives designers sound options for designs which inhibit fires.

Rheological behavior of antimisting kerosene additives has been investigated, yielding new methods of retaining treated fuel fire safety properties without sacrificing engine combustion efficiencies.

Antiskid systems performance has been examined with a view toward developing improved reliability concepts. Piloted simulation of aircraft operations in ground contact has been developed and enables investigation of control problems in otherwide hazardous operating regimes.

Infrared radiometry has been applied to the clear air turbulence detection and warning problem with encouraging success; the same instrument, with different filters, has shown promise as a wind shear warning instrument.

BASIS OF FY 1980 ESTIMATE:

Expansion of knowledge and understanding of meteorological hazards to aviation is a long-term process. FY 1980 research will include characterization of lightning strikes to aircraft in flight in terms of utilitarian value to aircraft systems designers as they concern themselves with protection of on-board avionics, structural elements, electrical power systems, and propulsion and fuel systems. Severe storms hazards will be characterized through flight penetrations of critical storm regions. Icing meteorological knowledge will be updated.

The advanced digital flight loads measuring equipment effort is to provide hitherto unavailable data on aircraft operation in the terminal area down to touchdown and during landing rollout. Icing tests of new airfoils will be conducted, and optimization of ground and airborne icing environment simulation will be pursued. A new understanding of elastomeric behavior of tires in the landing gear system will be sought.

As a result of the in-house assessment, an increased emphasis will be placed on research into the prevention of aircraft fires and the maximization of fire survivability.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Fluid and Flight Dynamics Research and Technology.........	14,495	16,500	16,500	20,700

OBJECTIVES AND STATUS:

The objective of the Fluid and Flight Dynamics Research and Technology program is to advance understanding of aerodynamic phenomena and improve predictive capability to permit increased performance optimization of advanced aircraft during early design stages.

In the area of computational fluid dynamics, significant advances are being made in the capability of computer codes to predict complicated flow situations and configuration geometries, and in applying the codes to specific analysis and design situations. During the past year, and in cooperation with the aircraft industry, a number of such codes were applied to significantly improve the performance of a number of existing, as well as conceptual, transport and military aircraft. In addition, improvements have been made in these user-oriented codes in terms of efficiency, flexibility, utility and accuracy. Concurrently, significant progress has been made toward the goal of achieving one-to-one correlation between wind tunnel and full-scale flight data through the elimination of tunnel wall interference effects and through a proper evaluation of the effects of tunnel airstream turbulence on boundary layer transition.

BASIS OF N 1980 ESTIMATE:

Intensive efforts in computational fluid mechanics will continue in N 1980. Computer codes will be developed to calculate inviscid and turbulent flows with limited and extensive regions of separation. An efficient user-oriented code will be generated for computing the Navier-Stokes equations for a variety of two and three dimensional geometries on vector processors (including the ILLIAC IV). Techniques will be developed for the simulation of boundary layer transition and turbulence in incompressible and compressible three-dimensional flows.

Future work will include the coupling of potential flow codes with advanced boundary layer codes and the incorporation of flow separation modeling. In the area of high-lift aerodynamics, theoretical methods will be developed to analyze and design multi-element airfoils and wings, and experimental tests will be conducted to verify the analysis. Theoretical research planned includes Reynolds stress modeling of multi-element airfoil drag problems and determination of the effects of transverse pressure gradients on boundary layers and wakes.

Aerodynamic test methods and instrumentation development efforts will continue to stress nonintrusive flow measurements such as holographic interferometry, laser velocimetry and infrared photography to provide data otherwise unobtainable, to improve data collection efficiency, and to gather data in a form more amenable to on-line analysis. Work in the integration of theory and experiment continues with emphasis centering about canard-wing interactions and high incidence forebody vortex flow problems. A major research and technology activity in the fluid and flight dynamics area will be the development of cryogenic technology and full-scale Reynolds number test techniques. This activity will be pursued to insure maximum utilization of the unique capabilities of cryogenic transonic tunnels.

Airframe noise research in FY 1980 will relate the general characteristics of airframe noise to aircraft configuration and operating conditions. Fluid dynamics and acoustics basic research will be conducted in the area of noise generation by turbulent flows. Viscous drag reduction schemes will be evaluated, including slot injection, longitudinal surface striations, and particle injection/recovery.

In the area of flight dynamics, experimental efforts in FY 1980 will be directed toward development of a forced oscillation dynamic stability measurement capability for high angles of attack and high Reynolds numbers. Analytical techniques will be developed for determining stability and control characteristics from flight test data.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Low-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology.	12,700	13,000	13,000	12,600

OBJECTIVES AND STATUS:

The objective of the Low-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology program is to provide advanced technology to improve the integrated aerodynamic performance, noise, stability, control, and flight dynamics of general aviation aircraft, advanced rotorcraft, and advanced vertical- and short-takeoff and landing (V/STOL) aircraft.

The ability to alleviate poor stall and spin characteristics of some general aviation aircraft through wing modifications, inducing a "flat top" lift curve, was demonstrated successfully, initially by full-scale wind tunnel tests and subsequently verified by flight tests. As part of the ongoing research on reduction of helicopter vibration, initial test results indicate the potential of a large reduction in hub loads through the use of higher harmonic control of blade pitch. In continuing investigations to evolve an effective jet-lift augmentation capability which can be incorporated practically in high performance VTOL configurations, large-scale static and wind tunnel tests were carried out on a complete representative model, in which high augmentation ratios--up to 1.7-- were achieved.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, general aviation efforts will continue to gain a better understanding of the components of drag associated with cooling of the propulsion system to enable improved overall aircraft performance. Further analytical, wind tunnel, and flight tests will be carried out on aircraft configurations having the potential for practical stall immunity and means for spin avoidance.

Rotorcraft research in FY 1980 will include theoretical, small-scale and/or large-scale wind tunnel tests of promising rotor concepts intended to reduce helicopter vibration, including individual blade control, adaptive multicyclic control, active feedback control, and aeroelastically configured rotors. Rotor-hub-pylon fuselage drag reduction studies will continue, initially through small-scale wind tunnel model tests. Development of methods for analyzing three-dimensional rotor flow fields including realistic modeling of viscous and compressibility effects will be initiated. Studies to develop a more complete understanding and prediction of rotor noise mechanisms will be continued. Initiated in cooperation with the FAA, NASA research helicopters with the capability to vary their stability characteristics will be used in flight investigations to update and refine civil terminal area operation certification criteria.

In FY 1980, in the area of advanced V/STOL aircraft, efforts will be accelerated to improve prediction of cruise and vertical-to-horizontal transition aerodynamics and ground effects with supporting key wind tunnel experiments to guide and verify the analytical approaches being derived. Emphasis will be placed on modeling tlie propulsion streams to consider propulsion-induced effects and airframe/propulsion system interactions.

	1978 Action	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
High-speed Vehicle Aerodynamics and Flight Dynamics Research and Technology.	11,905	13,000	13,900	14,100

OBJECTIVES AND STATUS:

The objective of the High-speed Vehicle Aerodynamics and Flight Dynamics Research and Technology program is to generate aerodynamic technology advancements needed to achieve safe, reliable, and economical high-speed civil aircraft and to establish and maintain technological superiority in military vehicles and systems.

The advantages of two-dimensional nozzles for future high performance aircraft have been assessed through studies, and test and simulator evaluations of modified F-15, F-17, and HiMAT aircraft. Results of these tests indicate that two dimensional nozzles offer reductions in drag and weight providing significant improvements in aircraft performance. In thrust vectoring technology, studies and simulation experiments have shown potential for greatly enhanced military mission performance. Hypersonic vehicle research studies continue to show capability for increased performance. Additional potential performance benefits require more realistic plume aerodynamics research, improved performance prediction techniques, and analytical methods for the Mach 6 to 8 flight regime.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $900 thousand reflects a realignment of funds within the Research and Technology Base to provide increased funds for wind tunnel testing in support of priority high speed research.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the interactive configuration aerodynamics effort will concentrate on optimizing the interaction of various advanced technologies that can improve overall configuration performance.

The combat vehicle and missile aerodynamic activities will continue to explore selected promising concepts such as noncircular two-dimensional nozzles. Wind tunnel testing of several refined nozzle concepts will be evaluated and the experimental data obtained will be used to evaluate the potential system performance benefits of instantaneous vectoring to enhance maneuverability and increase range through reducing the drag. Advanced aerodynamic concepts applicable to new missile design concepts will be investigated, with emphasis on missile aircraft integration.

The hypersonic aircraft aerodynamics and flight dynamics effort will continue to concentrate on establishing a valid aerothermodynamic data base for future hypersonic vehicle concepts. The activity will include selected hypersonic wind tunnel model tests and tests of subscale components. New methods of testing complete configurations in simulated hypersonic environment will also be investigated.

In FY 1980, as part of interagency and industrial assistance activities, a broad range of experimental investigations, including use of wind tunnels and simulators, augmented with theoretical analyses will be conducted. These efforts will provide support for a broad range of aircraft and missile configurations. As required, joint activities with other Government agencies will be conducted to insure and maintain preeminence of current and future military air vehicles.

The FY 1980 remotely piloted research aircraft technology activities will concentrate on the development of new control concepts for high speed testing and enhancement of pilot control of remotely piloted research vehicles.

Flight experiment support activities will also be conducted to provide a broad base of flight experiments and related efforts applicable to generic problems of high speed vehicles.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Human-Vehicle Research and Technology	5,000	5,600	5,600	5,700

OBJECTIVES AND STATUS:

The objective of the Human-Vehicle Research and Technology program is to provide a research and technology base for solutions to the human-factors related problems in influencing the growth, efficiency, and safety of air transportation, The program has three areas of emphasis: flight management, flight simulation technology and human response to noise.

During FY 1979 a number of research studies are being conducted within the major areas. Included are joint programs with the Federal Aviation Administration to enhance aircrew performances and alleviate the potential for human error.

BASIS OF FY 1980 ESTIMATE:

In the flight management area, joint Federal Aviation Administration programs will continue in FY 1980. Studies to assess advanced cockpit warning systems and single-pilot flight operations in advanced air traffic control environments will be initiated. Experimental activities associated with the cockpit traffic information display concept will continue. Work will also begin on the development of models characterizing information processing and decisionmaking processes which are necessary to establish human factors guidelines for automated systems. Studies to assess single-pilot flight operations in advanced air traffic control environments will be initiated.

Flight simulation technology will include efforts to quantify and validate advanced methodologies for conducting large-scale, full-mission simulations, Experimental studies to quantify perceptual models of visual performance in degraded visual environments will continue.

The human response to noise effort will continue to assess the utility of community response models through laboratory and field studies. Improved multiple event noise descriptions will be examined in laboratory settings to establish their validity.

BASIS OF FUND REOUIREMENTS:

SYSTEM STUDIES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
System Studies...	3,000	3,000	3,000	3,200

OBJECTIVES AND STATUS:

System studies are conducted primarily as a means of identifying the need for, and assessing the impact of, technology advances. The objectives of aeronautics system studies are to determine the feasibility, technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems through mission, system and conceptual design studies. The studies integrate the mutual effects of technology and a wide range of related factors.

Significant recent results include identification of the technology needs of the manufacturers and operators of small "commuter" transport aircraft, quantitative evaluations of the potential impact of technology on future air cargo aircraft and systems, and initial assessments of the applicability of air cushion landing gear and variable wing camber to various aircraft classes.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, studies of civil air transportation systems will emphasize the use of advanced technology for the reduction of operating and acquisition cost of transport aircraft and for the enhancement of airborne systems dedicated to cargo movement. Specific studies will address long-haul air cargo vehicles concepts and their unique technology requirements, small transports for low-density short-haul and commuter use, and future total transportation systems.

Studies of future military aviation systems will be consistent with needs of the military services, with emphasis on vertical takeoff and landing (Navy) and cruise missiles (Air Force).

Studies in FY 1980 of utility aviation systems will emphasize the impact of advanced rotorcraft technology in public service/rescue and heavy-lift helicopters.

Systems analysis methodology and support activities will continue to emphasize air transportation demand, comparisons and integration with other modes, and the understanding of technology transfer processes in the aviation industry.

Studies of general aviation systems in FY 1980 will explore the aeronautical technology needs and opportunities in future general aviation aircraft and propulsion systems.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Materials and structures systems technology..........	7,095	4,500	4,500	6,000	9-20
Propulsion systems technology........................	22,150	28,400	28,400	20,600	9-21
Avionics and flight control systems technology.......	1,730	2,400	2,400	1,800	9-23
Aircraft operating systems technology................	7,020	9,300	9,300	11,700	9-24
Aerodynamic vehicle systems technology...............	3,740	5,600	5,600	10,500	9-25
Human-vehicle systems technology.....................	800	800	800	400	9-27
Advanced civil aircraft systems technology...........	21,700	20,400	18,340	28,520	9-27
High-performance aircraft systems technology.........	9,000	9,000	11,060	16,580	9-29
Rotorcraft systems technology........................	2,530	5,245	5,245	10,000	9-31
Total..	75.765	85.645	85.645	106.100	

Materials and Structures Systems Technology...........	7,095	4,500	4,500	6,000

OBJECTIVES AND STATUS:

The objective of the Materials and Structures Systems Technology Program is to accelerate the transfer of advanced materials and structures technologies to application in the design of aircraft structures and engines.

In the Materials for Advanced Turbine Engines (MATE) effort, directionally solidified eutectic turbine blades completed their 150-hour Federal Aviation Administration qualification test and will be on the bill of materials for the widely used TFE 731 general aviation engine. Single-crystal turbine blades are currently being produced for engine testing.

In the Aeroelasticity of Turbine Engines (ATE) activity, significant progress has been made in developing analyses to predict supersonic flutter and stall flutter of turbine blades and flutter boundary mapping of fan blades.

The Fire Resistant Materials Engineering (FIREMEN) effort has developed new resins, foam fillers and adhesives with vastly improved flammability resistence and low smoke and toxic gas yields.

BASIS OF FY 1980 ESTIMATE:

The MATE effort involves the identification of promising high temperature materials for production and development of engineering data followed by engine testing. During FY 1980, the emphasis will be on demonstrating the performance of single-crystal turbine blades, an advanced powered metallurgy disk, an advanced directionally solidified turbine blade, and an advanced turbine blade tip seal. The goal is to reduce the specific fuel consumption in engines by 1.5 percent using these materials.

The Integrated Program for Aerospace Vehicle Design (IPAD) efforts in FY 1979 will evaluate the complex software requirements for the system. In FY 1980, the detailed design of all first-level software components will be completed, and the preliminary version of the data base management system will be released for industry evaluation,

The ATE technology activity is a joint Air Force/NASA effort to improve the understanding and prediction capability for aeroelastic instability phenomena in turbine fan stages. The FY 1980 effort includes correlation of analytical predictions with experiments on the vibratory modes of blade, shroud, and disk systems of advanced fans and compressors and completion of the development of a prediction technique for blade flutter.

The FIREMEN activity was designed to accelerate the development of fire-resistant, low toxicity polymers for use in commercial aircraft. In FY 1980, evaluation of materials systems developed earlier will continue. In particular, tests of materials used in panels, enclosures, windows, seat fabrics, moldings and cushioning will provide data needed by designers. Selections can then be made for the safest combinations of materials to help resist fire, smoke and toxic gases.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propulsion Systems Technology	22,150	28,400	28,400	20,600

OBJECTIVES AND STATUS:

The objective of the Aeronautical Propulsion Systems Technology program is to achieve increased performance and efficiency of the complete propulsion system through integration of advanced propulsion components.

In the Engine Component Improvement activity, all performance improvement concepts for the JT8D, JT9D and CF6 engines are under development. In the Variable Cycle Engine Components effort, the noise reduction benefit of coannular nozzles has been verified in full-scale tests.

BASIS OF FY 1980 ESTIMATE:

The Helicopter Transmission Systems Technology efforts will provide a systems evaluation of many advanced technology components which have been under investigation for a number of years. Design work on an advanced technology gear-type transmission and a traction-drive transmission was completed, and in FY 1979 these designs were translated into test articles. In FY 1980, these two transmissions will undergo performance testing.

The Broad Specification Fuels Technology activity is aimed at demonstrating the compatibility of broad specification fuels, which were defined and characterized in the Research and Technology Base, for operation in current and next generation commercial jet engines. Combustor design definition and conceptual evaluation are currently underway. In FY 1980, the combustor design requirements and criteria will be completed.

The Variable Cycle Engine (VCE) Components effort will continue to evaluate advanced technology components which offer significant performance benefits combined with reduced noise and emission characteristics. During FY 1980, the last year of funding for this activity, the focus will be on the aero/acoustic performance and component interactions and compatibility of a core-driven third-stage fan and an outer-stream jet suppressor operating in conjunction with a coannular plug nozzle. The operational and emission characteristics of an advanced, less complex duct burner configuration will also be investigated.

In the Engine Component Improvement effort, detailed technical and economic feasibility analyses of potential performance improvement concepts were completed in FY 1978. Development has been initiated on the seventeen most promising technology concepts. In FY 1980, the last year of funding for this activity, component rig tests, engine ground tests and flight tests will be conducted to evaluate the selected design concepts, which can then be promptly introduced into production engines to reduce fuel consumption on the order of 5 percent in current commercial transports. Several near-term fuel-saving concepts have already been selected for incorporation in the CF6 and JT9D engines which will power the new Boeing 767 transport aircraft. Development work will continue in engine diagnostics technology to identify and quantify the causes of performance deterioration. Component sensitivity studies will be conducted, based on historical and test data compiled earlier. Analytical models and correlations will be developed to aid in the analysis of deterioration in existing engines, as well as in the design of future engines.

The Stratospheric Cruise Emission Reduction effort establishes and demonstrates the technology necessary to reduce exhaust emissions from modern gas turbine aircraft engines to environmentally acceptable levels over the entire subsonic flight envelope, with minimum adverse effects on performance, weight and complexity. Special emphasis is being placed on reductions in stratospheric cruise emissions of oxides of nitrogen. The assessment of promising combustion system concepts will be completed in M 1979. In FY 1980, experimental evaluations of the most promising concepts will be completed. These concepts will have as a major goal an emission level of 3 grams of nitrogen oxide per kilogram of fuel at cruise conditions. This value represents a tenfold reduction compared to current production engines.

The Advanced Turboprop program will provide the technology necessary for advanced high-speed propellers capable of providing up to 25 percent fuel savings relative to current high-bypass-ratio turbofan engines. In FY 1980, the design and fabrication of a propeller model optimized for aerodynamic, acoustic and structural considerations will be completed. Flight tests will be conducted with a Jet Star aircraft to assess the near-field acoustic characteristics of an advanced propeller model. The development of fuselage noise attenuation concepts selected from an experimental screening process will continue. The absolute level of propeller slipstream/wing interference drag will be established for a specific configuration. Analytical evaluations will be made of potential aircraft, engine and propeller drive system mechanical components.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Avionics and Flight Control Systems Technology	1,730	2,400	2,400	1,800

OBJECTIVES AND STATUS:

The objective of the Avionics and Flight Control Systems Technology program is to apply the fundamental knowledge gained in the Research and Technology Base to demonstrate technology readiness and to promote the transfer of advanced avionic systems techniques to the aircraft industry through experimental testing and verification in a realistic environment.

In the Digital Fly-by-Wire program, flight evaluation of an adaptive control law is underway which will permit system adaptation to changes in flight conditions. In the General Aviation Advanced Avionics Systems program, the selection of the conceptual system design has been made and a contract initiated to fabricate an evaluation model.

BASIS OF FY 1980 ESTIMATE:

The Digital Fly-by-Wire activity provides for development and evaluation of an all electronic, redundant aircraft flight control system in an actual flight environment.

The principal emphasis is on reduced weight and fuel consumption, and on improved performance and operational flexibility. In FY 1980, flight evaluations of a failure management system will be completed and preliminary ground tests conducted to analyze the susceptibility of advanced digital avionic systems to lightning.

The General Aviation Advanced Avionics Systems effort is aimed at providing a totally integrated, advanced, low cost avionics system to enhance the safety, reliability, and utility of future general aviation aircraft. During FY 1980, a model of a conceptual system design will be fabricated and system evaluation tests initiated.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aircraft Operating Systems Technology.....................	7,020	9,300	9,300	11,700

OBJECTIVES AND STATUS:

The objectives of the Aircraft Operating Systems Technology program are to demonstrate and evaluate advanced integrated aircraft system concepts for navigation, guidance, control, and cockpit displays which are technically advanced with substantial improvement in system architecture and capability to meet the performance demands of future air traffic control (ATC) systems. This technology effort involves analytical studies, simulations, and application of advanced technology through the hardware-flight test phase to reduce risk to the point where the technology will be accepted and applied to future aircraft configurations for safer and more productive flight operations. The effort is carried out utilizing the advice and cooperation of the airlines, aviation industry, and the FAA.

Emphasis in FY 1979 is being placed on air-carrier transport-type aircraft (B-737) and rotorcraft (UH-1H, CH-47), and XV-15 Tilt Rotor Research Aircraft) equipped with advanced displays and integrated digital avionics systems which are dedicated to experiments that explore efficient descent and approach paths, landing in adverse weather, precision flight path control, and interfaces between the pilot and the ATC system.

BASIS FOR FY 1980 ESTIMATE:

Operating system technology studies will address, in a joint effort with FAA, problems and promising methods for certification of advanced digital flight control systems. Piloted, real-time mission simulations using representative actual flight hardware and software will be conducted to evaluate system reliability and fault tolerance. Studies will also be performed to identify the potential application of advanced technology to the safe operation of single-pilot general aviation aircraft in adverse weather.

In close coordination with the FAA, the Terminal Configured Vehicle (TCV) research activities in airborne systems and operational procedures will be aimed at adding capacity to the ATC system, supporting ATC system evolution, maximizing utilization of congested airspace, improving capability in adverse weather, and improving fuel conservation. Investigations of the capacity, efficiency, and safety potential of Cockpit Display of Traffic Information (CDTI) with elements envisioned for use in the 1985-1995 ATC systems will be stressed in FY 1980.

In a joint effort with the Army and the FAA, the Rotorcraft Operating Systems program will demonstrate new technology applied to instrument flight rules (IFR) flight operations for civil and military rotorcraft.

This activity will include instrument meteorological condition landings using advanced guidance, control and displays; definition of ATC concept and operational procedures for medium-density operations to closely spaced oil rigs; and exploration of concepts and development of self-contained navigation and guidance concepts for IFR approaches to remote sites.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Aerodynamic Vehicle Systems Technology	3,740	5,600	5,600	10,500

OBJECTIVES AND STATUS:

The objective of this program is to investigate the potential application of improved aerodynamic concepts to existing or future aerodynamic vehicle systems and to demonstrate, in flight, selected concepts that show particular promise for improving aircraft performance, efficiency, safety, utility and operating effectiveness.

The feasibility of reducing the safe takeoff and landing separation distance between aircraft in the presence of trailing wake vortices to three miles or less has been indicated by coordinated laboratory and flight investigations conducted under the Wake Vortex Minimization program. A number of promising aerodynamic concepts to reduce the generation of wake vortices have been identified, but a fundamental understanding of the phenomena does not yet exist.

The second phase of the Laminar Flow Control (LFC) activity, a validation of LFC concepts and configurations, was initiated in FY 1979. This phase will expand the technology development to provide added focus on key areas such as aerodynamics, structures, and suction systems. A contract will be awarded during FY 1979 to modify a suitable aircraft for a leading-edge glove flight test to demonstrate laminar flow compatability with supercritical airfoils under actual flight conditions which cannot be simulated in the wind tunnel.

BASIS OF FY 1980 ESTIMATE:

In the Wake Vortex Minimization, the FY 1980 activity will emphasize fundamental studies to determine aerodynamic design factors that influence the formation and destructive interference of multiple vortex systems. A generalized wind tunnel model will be used to relate wing geometry to the near-field vortex flow characteristics and to provide input data to computational techniques which will be used to provide aircraft designs optimized for minimum wake vortex effects.

In Laminar Flow Control, efforts will continue to develop the technology required for a practical, reliable, and easily maintained system. In FY 1980, contracts will be awarded for the detailed design and test of two wing box structural concepts, including outer cover panels and related ducting. Wind tunnel tests will be conducted on a swept-wing supercritical airfoil to investigate boundary layer control and flow laminarization by using suction through wing surface slots. Work will continue toward modification of a small aircraft with a wing glove for flight evaluation of laminar flow control/supercritical airfoil compatibility.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Human-Vehicle Systems Technology..........................	800	800	800	400

OBJECTIVES AND STATUS:

The objectives of this program are to reduce the frequency of aviation incidents and accidents attributable to human error and investigate techniques and operational procedures that will ensure optimum performance in multicrewmember aircraft, and to continue to operate an Aviation Safety Reporting System (ASRS) at the request of the Federal Aviation Administration,

In FY 1979, investigations are being conducted to identify information transfer deficiencies between air and ground personnel. Analytical and experimental methods for assessing the safety contribution of new procedures and systems and the effectiveness of full mission simulation as a training technique are under investigation. A computer-based data management system is being used to aid in the analysis of safety reports. Emphasis is being placed on analysis of factors contributing to air crew and controller error.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, full mission simulation studies will be continued examining solutions to information transfer and decision-making problems encountered during complex flight phases. Operation of the Aviation Safety Reporting System will be continued into FY 1980. In late FY 1980, FAA and NASA will give consideration to continuation, transfer to FAA or termination of this reporting system. In addition, new research investigations, based on the problems identified from ASRS data, will be initiated.

Advanced Civil Aircraft Systems Technology.................	21,700	20,400	18,340	28,520

OBJECTIVES AND STATUS:

The objectives of the Advanced Civil Aircraft Systems Technology program are to provide a technology base for the design and operation of advanced transport and special-purpose civil aircraft, using promising technologies generated in the Research and Technology Base program, and to exploit military-developed aircraft and technologies for civil applications.

In the Energy Efficient Transport (EET) activity, contracts for the second phase effort were awarded during FY 1979 to continue advanced aerodynamics and active controls technology programs by three major airframe manufacturers, The L-1011 aircraft wing tip extension/active controls flight tests were completed. These tests evaluated maneuver load control, elastic mode suppression, gust load alleviation, and aircraft performance. Modifications to the KC-135 airplane will be completed and winglet flight tests initiated. Test and evaluation of a fault-tolerant computer engineering model will be conducted during FY 1979, and NASA wind tunnel tests for advanced aerodynamics technology and parametric controls model evaluation will continue.

In the Quiet, Propulsive-Lift Systems Technology efforts, an analysis was conducted to establish characteristics of advanced flight control and display concepts for improving terminal area flight control and handling qualities. Flight experiments will be continued during FY 1979 with Augmentor Wing and Twin Otter Research Aircraft, exploring applicability of the microwave landing system to STOL operations, and alternate digital avionics functional configurations and terminal area operational concepts. Work has been initiated to define specific Quiet Short-Haul Research Aircraft (QSRA) flight experiments which will provide a data base for improved powered-lift flying qualities criteria and flight control systems.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $2,060 thousand reflects a transfer of the vertical takeoff and landing (VTOL) Systems Technology activity to the High-Performance Aircraft Systems Technology program.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, studies will be conducted to investigate the applications of advanced technology to advanced civil passenger and cargo transport in such a way as to decrease initial acquisition and recurring operating costs while maintaining safety, maintainability and environmental compatibility.

In the second phase of the Energy Efficient Transport (EET) effort, work will continue with major airframe contractors to develop, refine, and evaluate advanced aerodynamic and active control technologies for near-term and future application to derivative and new subsonic transport aircraft. In FY 1980, advanced winglet concepts will be wind tunnel tested to establish cruise aerodynamic performance and basic wing and high lift system/high Reynolds number models will complete wind tunnel evaluation of low-speed aerodynamic characteristics. Aeroelastic wing/flight control system wind tunnel tests will be completed and flight tests initiated. In the area of high reliability/high maintainability flight controls, advanced computer evaluations will continue, and data distribution system architecture evaluation studies will be completed.

The Quiet, Propulsive-Lift Systems Technology efforts will complete NASA participation in the USAF Advanced Medium STOL Transport (AMST) program to obtain handling qualities and flight systems performance data for establishing civil certification criteria for powered-lift aircraft with a maximum lift coefficient of 3.5. Terminal area flight operations research with the Augmentor Wing aircraft and STOLAND digital avionics research system will be completed. Documentation of the QSRA baseline flight characteristics will be completed in preparation for future flight research experiments which will include systems investigations to enhance the design data base for efficient all-weather terminal area operations and the expansion of the certification criteria data base.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
High-Performance Aircraft Systems Technology...............	9,000	9,000	11,060	16,580

OBJECTIVES AND STATUS:

The objective of the High Performance Aircraft Systems Technology program is to perform the extensive research, including wind tunnel, ground-based simulator and flight tests, required to generate engineering and design data applicable to advanced high-performance, high-speed aircraft for civil and military applications.

The vertical takeoff and landing (VTOL) Systems Technology program will establish a broad technology base for anticipated and potential military and civil VTOL applications involving high-speed cruise flight. Emphasis has been placed on analytical and simulator investigations, tests of advanced propulsion concepts, and wind tunnel studies of advanced configurations. The Supersonic Cruise Research program continued the detailed study of high potential technologies in aerodynamics, propulsion, structures and materials fabrication. A major effort was also directed to technology associated with the integration of the recently acquired variable-cycle engines data with the advanced inlets, the coannular nozzles, the nacelle and various airframe platform configurations. Advanced flight investigations continue in the areas of airframe/propulsion integration, the mission adaptive wing and high angle-of-attack research. In FY 1979, airframe/propulsion integration investigations are being conducted with the F-15 aircraft to provide basic performance information. In the joint NASA/Air Force mission adaptive wing effort, initial wind tunnel testing has identified the potential for large performance gains for fighter aircraft over the entire flight envelope using variable camber and variable sweep. In the joint NASA/Navy high angle-of-attach experiments, a NASA developed aileron-to-rudder interconnect system has been evaluated in ground simulation and appears to exhibit a potential solution to the recurring F-14 high angle-of-attack controllability problem.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $2,060 thousand reflects a transfer of the vertical takeoff and landing (VTOL) System Technology activity from the Advanced Civil Aircraft Systems Technology program.

BASIS OF N 1980 ESTIMATE:

In FY 1980, the VTOL Systems Technology program will be directed to configuration aerodynamics concepts to be evaluated in both subsonic and supersonic wind tunnel tests, a large-scale model tests in the 40 by 80-foot wind tunnel, and a large-scale deflectable nozzle to be tested with both subsonic and supersonic experimental propulsion systems on a static test stand to determine criteria for deflecting thrust through 90°. These efforts will complement ongoing efforts in ship motion/aircraft flight control studies, configuration definition and refinement with advanced propulsion concepts.

During FY 1980, the Supersonic Cruise Research efforts will emphasize refinement of aerodynamic configurations over the full operational speed range using analytical techniques coupled with an extensive wind tunnel testing program, improved inlet designs and installation studies for variable-cycle engines, advanced nozzle concepts including coannular configurations with suppression, the integration of the propulsion system/nacelle to the airframe, and the continuation of advanced titanium structures design and fabrication techniques.

The FY 1980 Advanced Flight Experiments efforts will continue research into airframe propulsion integration emphasizing testing of new information and control concepts for advanced aircraft. Following the phase-out of the YF-12 research aircraft, the F-15 will be utilized to integrate advanced controls for engine, inlet and aircraft guidance to maximize performance at all flight conditions and to reduce pilot workload. The ongoing joint effort with the Air Force in FY 1980 will be directed to the design and construction of a mission adaptive wing for the F-111 aircraft. This program is an attempt to combine, in an actual wing, the variation in sweep angle with in-flight variations in wing camber to achieve and demonstrate maximum performance over the full operational speed range of the aircraft. In FY 1980, the Advanced Flight Experiments activity also will continue the NASA/Navy high angle-of-attack flight experiments using an F-14 aircraft to investigate the interconnect system.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft Systems Technology	2,530	5,245	5,245	10,000

OBJECTIVES AND STATUS:

The objective of the Rotorcraft Systems Technology effort is to conduct broad-based research on promising rotorcraft systems for use in future civil and military applications. The major areas of concern are rotorcraft structural systems; propulsion; guidance, control and navigation; advanced rotor system concepts; and advanced concepts for vibration and noise reduction. The activity involves coordinated research efforts in analysis, model testing, simulation, large-scale wind tunnel testing and flight testing of rotorcraft and subsystems. A key element is the verification of analytical design methods by ground-based and in-flight experiments.

The two new Rotor System Research Aircraft (RSRA) vehicles are being brought to a state of readiness for research flight investigations. Substantial progress is being achieved in concentrating the NASA experimental rotorcraft and associated test support equipment at the Ames Research Center.

BASIS OF FY 1980 ESTIMATE:

A major effort will essentially complete the incorporation and checkout of the flight test capabilities planned for the RSRA vehicles and provide comprehensive flight test data on the delivered rotor system in both the helicopter and compound flight modes. Efforts will begin in FY 1980 to enhance the capability of the newly acquired Vertical Motion Simulator to perform effective, high fidelity rotorcraft simulations to develop criteria for improved design and piloting quality criteria. Modifications will begin on existing helicopter rotors which can be readily adapted for flight test on the RSRA, and which would benefit significantly from the expanded test envelope capability of this research vehicle. Conceptual and preliminary design studies will be initiated for a general purpose research rotor, which may lead to the first new rotor for far-term investigation on RSRA.

The XH-59A helicopter incorporating the Advancing Blade Concept will be tested in the Ames Research Center 40 by 80-foot wind tunnel to assess potential for drag reduction and to correlate flight test data obtained in a joint Army/Navy/NASA program, The performance and loads of a new bearingless full-scale rotor will be evaluated in the tunnel.

BASIS OF FUND REQUIREMENTS:

EXPERIMENTAL PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Energy efficient engine.	18,500	43,150	43,150	55,600	9-32
Highly maneuverable aircraft technology	2,480	1,500	800	1,500	9-33
Composite primary aircraft structures...............	25,150	20,000	20,000	16,400	9-34
Quiet, clean, short-haul experimental engine.	600	105	105	---	9-35
Tilt rotor research aircraft..	2,300	500	500	---	9-35
Quiet propulsive-lift technology	2,400	1,000	1,700	---	9-36
Total.............................	51,430	66.255	66.255	73.500	

Energy Efficient Engine.	18,500	43,150	43,150	55,600

OBJECTIVES AND STATUS:

The Energy Efficient Engine (EEE) program is directed toward the development and demonstration of the technology for achieving significant reductions in both specific fuel consumption and direct operating cost in future turbofan engines.

The EEE preliminary design and integration studies, completed in January 1978, established the engine cycle and configuration characteristics around which the subsequent Component Development and Integration phase of the program was structured. This phase was initiated early in 1978 with contract awards to the General Electric Company and the Pratt & Whitney Aircraft group of United Technologies Corporation. The preliminary design of the EEE flight propulsion systems, a major program milestone that establishes the configuration baseline for all component and subsystem interfaces, has been completed. Initial experimental efforts on several components have verified efficiency goals and substantiated design approaches.

BASIS FOR FY 1980 ESTIMATE:

Detailed aerodynamic and mechanical design, subcomponent rig testing, fabrication of core and integrated core/low spool components and testing of core components will be the dominant activities in FY 1980. Core components will be fabricated and tested in full scale to demonstrate performance. The core engine system will be designed, fabricated, assembled and tested. Modifications will be made to the core by incorporating new technology from parallel component development work. All available technologies will be integrated and demonstrated in a core/low spool system test.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Highly Maneuverable Aircraft Technology	2,480	1,500	800	1,500

OBJECTIVES AND STATUS:

The objective of this joint effort with the Air Force is to provide low-cost flight research vehicles to promote and stimulate the application of new high-risk (laboratory) technology for the design of future vehicles. The program will provide two unmanned, subscale, remotely piloted, low-cost flight research vehicles which will be extensively flight tested. The flight test program will concentrate on the key new technologies incorporated into the Highly Maneuverable Aircraft Technology (HiMAT) design, advanced airfoils with close coupled canards, and aeroelastic tailoring.

Both research vehicles have been fabricated and delivered to NASA, and are undergoing preflight checkouts. The first flight is scheduled for June 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease reflects rephasing between HiMAT efforts and the Quiet Propulsive Lift Technology efforts in FY 1978/1979. HiMAT efforts were increased toward the end of FY 1978 by offsetting adjustments in the Quiet Propulsive Lift Technology activity.

BASIS OF N 1980 ESTIMATE:

In FY 1980, the flight research activities will address the vehicle test envelope definition and the verification of the basic design methodology. Approximately eight flights are planned to explore the performance envelope of the HiMAT vehicles.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Composite Primary Aircraft Structures................	25,150	20,000	20,000	16,400

OBJECTIVES AND STATUS:

The objective of the Composite Primary Aircraft Structures program is to develop the technology needed to assure early use of advanced composite materials in future transport aircraft. The weight savings attainable with composites can result in a 10-15 percent fuel savings. The cost economy and long-term reliability and maintainability of composites will be demonstrated by designing, fabricating, testing, certificating and installing composite components on scheduled airline aircraft.

The DC-10 rudder effort is now complete, and Douglas is considering incorporation of the composite component into production of future aircraft. The B-727 elevator program is now in the full-scale component test phase and will be completed in FY 1979. The other four components (DC-10 vertical stabilizer, L-1011 aileron and vertical stabilizer, and B-737 horizontal stabilizer) are in the design and manufacturing development phase. The preliminary wing design studies are complete, indicating a potential 25-percent weight saving and a 15-percent fuel saving for a new design. Interim results of the risk assessment of accidental release of carbon fibers from aircraft indicate the risks to be lower than originally estimated. Final results of the risk assessment will be available in FY 1980.

BASIS OF FY 1980 ESTIMATE:

Four of the six component activities will continue in FY 1980. The manufacturing development will be completed for the DC-10 vertical stabilizer and full-scale test components fabricated. The component tests for the B-737 horizontal stabilizer will be completed, and five flightworthy units fabricated; manufacturing development and ground tests for the L-1011 aileron and vertical stabilizer will be completed; and the carbon fiber release risk assessment will involve fire testing of full-scale aircraft structures. Further development of modified matrix and fiber materials will also be continued to minimize carbon fiber release.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Quiet, Clean, Short-Haul Expe ime tal Engine..	600	105	105	---

OBJECTIVES AND STATUS:

The objective of the Quiet, Clean, Short-Haul Experimental Engine (QCSEE) program is to consolidate and demonstrate the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable powered-lift, short-haul aircraft. The QCSEE program includes the design, fabrication and testing of two experimental turbofan propulsion systems, suitable for "under-the-wing" and "over-the-wing" externally blown-flap powered-lift aircraft installations.

The "over-the-wing" and "under-the-wing" propulsion system test activities at the General Electric Company test facility were completed in June and July 1978, respectively. These tests verified achievement of the major noise reduction goals for QCSEE. Many other advanced technology features such as a variable pitch composite fan, a lightweight integrated composite nacelle, gear reduction drives and integrated digital controls were also successfully demonstrated during these tests. Contractor efforts for design, fabrication, test and delivery of the propulsion systems to NASA were successfully accomplished.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Tilt Rotor Research Aircraft...........	2,300	500	500	---

OBJECTIVES AND STATUS:

The objective of the joint Army/NASA Tilt Rotor Research Aircraft (TRRA) program is to design, fabricate and flight test two research aircraft and to perform a proof-of-concept flight program to 'verify tilt rotor technology for application to the design and operation of civil and military aircraft. One of the primary objectives is to verify rotor/pylon/wing aeroelastic stability over the entire operational envelope. This program is based on a series of research and technology activities which began with the XV-3 tilt rotor flight tests in the 1950's.

The first of two XV-15 tilt rotor aircraft was delivered to Ames Research Center in March of 1978 for full-scale tests in the 40 by 80-foot wind tunnel. The tests were completed in June 1978 with all dynamic systems operating satisfactorily to speeds of 180 knots. Stable rotor/pylon/wing aeroelastic coupling predictions were verified. Vehicle drag was somewhat higher than expected and a tail buffet problem was uncovered and documented at speeds of approximately 80 to 100 knots. Solutions have been identified and the problem will be corrected in FY 1979.

The second of the two aircraft has completed ground tie-down tests and is in final preparation for contractor flight tests at Bell Helicopter Textron. This aircraft will be delivered to the NASA in FY 1979 and proof-of-concept flight program will begin in the fourth quarter of FY 1979 and will be continued throughout FY 1980. Funding for operational tests will be covered under the Aircraft Operating Systems Technology Activity in FY 1980. The flight testing will be conducted by a joint Army/NASA Project team. After the Government flight tests, the TRRA will be used as a facility for advanced technology flight tests.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Quiet Propulsive-Lift Technology......................	2,400	1,000	1,700	---

OBJECTIVES AND STATUS:

The objective of the program is to generate and verify a design and certification technology data base for efficient, quiet, short-haul transports with short takeoff and landing capabilities. Propulsive lift offers the most effective means of accomplishing this objective and offers potential for airport congestion relief, community noise reduction and operational improvements for civil and military transports. Research includes experiments in aerodynamics, propulsion, handling qualities, noise, flight control systems, information displays and operations.

The Boeing Commercial Airplane Company completed the design of the Quiet Short-Haul Research Aircraft (QSRA) in August 1977. Aircraft fabrication and assembly were completed in February 1978. The first flight of this research aircraft was accomplished in July, followed by delivery to NASA and initiation of proof-of-concept flights in August 1978. In FY 1979, the proof-of-concept flight tests will be completed.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $700 thousand reflects rephasing between the FY 1979 Quiet Propulsive-Lift Technology efforts and the FY 1978 Highly Maneuverable Aircraft Technology experimental requirements. The total funding for Quiet Propulsive-Lift Technology has not changed.

SUMMARY:

After the completion of the Quiet Short-Haul Research Aircraft's proof-of-concept flight tests in FY 1979, this unique research vehicle will be available for use in technology investigations to be conducted in the Advanced Civil Systems Technology activity.

SPACE
RESEARCH AND
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Research and technology base	65.505	71.700	71.795	77.100	10-3
System studies	2.000	2.000	2.000	2.200	10-16
Systems technology programs	5.a00	7.900	7.900	16.000	io 18
Experimental programs	15.395	17.700	16.605	18.100	10-21
Standards and practices	9.000	9.000	9.000	3.000	10-22
Total	97.700	108.300	107.300	116.400	
Distribution of Program Amount by Installation:					
Johnson Space Center	4.499	5.300	5.001	9.440	
Marshall Space Flight Center	6,846	7.500	a.801	6.500	
Goddard Space Flight Center	5.303	a.a00	7.539	9.300	
Jet Propulsion Laboratory	24.051	23.300	25,018	24.600	
Ames Research Center	a.563	9.700	10.007	9,840	
Dryden Flight Research Center	40	---	---	---	
Langley Research Center	25.132	22.700	25.287	27.400	
Lewis Research Center	19.028	26.600	22.335	25.420	
Headquarters	4,238	4.400	3.312	3.900	
Total	97.700	108.300	107.300	116.400	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Research and Technology program are to provide the technology base necessary to support current and future space activities; to formulate technology options for the future; and to advance approaches for further reducing the costs of space activities.

The FY 1980 program supports these objectives by stressing the technology areas judged to be most critical by advisory groups, a special in-house assessment, and in-house users of the technology. The program is designed to develop the technology needed to enhance planned missions and to enable future missions which are beyond current capabilities, with emphasis on increasing performance and reducing cost and risk in the areas of information systems, spacecraft systems, power systems and transportation systems. When required, the program demonstrates the readiness of new technology to assure its acceptance for utilization on planned missions.

CHANGES FROM FY 1979 BUDGET ESTIMATES:

The decrease of $1 million reflects the Space Research and Technology portion of the Congress' general reduction in NASA's FY 1979 appropriations request.

BASIS OF FUND REQUIREMENTS:

In FY 1980, a strong research and technology effort will be maintained in the disciplinary areas of materials, structures, sensing and detection, guidance and control, data reduction and distribution, chemical and electric propulsion, space energy systems and aerothermodynamics to meet the needs of current and future space activities. Systems Studies will be pursued to investigate future space mission alternatives and to identify and evaluate the technology requirements of future missions.

Systems Technology efforts will emphasize extending the temperature limits for composite materials to allow their use on advanced space transportation systems; providing advanced technology in materials, structures, assembly, and controls for potential future NASA space missions; definition of system requirements, configurations and techniques for efficient and timely transfer of space acquired data to the user community while reducing costs; and demonstration of the technology readiness of an advanced planetary orbiter spacecraft propulsion system which utilizes high-performance, space-storable, fluorine-hydrazine propellants. Inaddition, emphasis will be placed on developing the technology for advanced space communication systems.

In the Experimental programs, under the Space Technology Shuttle/Spacelab program, experiments will be integrated with the Long Duration Exposure Facility (LDEF) and the LDEF will be ready for integration with the shuttle. The development and integration of experiments to be conducted on early Shuttle and Spacelab missions will be continued. The development and integration of experiments which will utilize the Shuttle orbiter as a research vehicle to conduct multidisciplinary research will also continue.

In the standards and practices area, emphasis is being placed on completion of standard hardware for use on multiple missions, product improvement through component upgrading, and on improvement of program practices, concentrating on such areas as specifications, testing and flight project analysis.

BASIS OF N 1980 ESTIMATE:

RESEARCH AND TECHNOLOGY BASE

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Materials research and technology..................	7,100	7,500	7,500	7,800	10-4
Structures research and technology.................	6,000	7,200	7,200	7,700	10-5
Sensing and detection research and technology......	4,400	4,950	4,895	5,400	10-6
Guidance and control research and technology.......	3,500	3,850	4,000	4,300	10-7
Data reduction and distribution research and technology....................................	6,500	8,300	8,300	9,700	10-8
Chemical propulsion research and technology........	8,100	9,200	9,200	9,900	10-10
Electric propulsion research and technology........	6,300	7,000	7,000	7,500	10-11
Space energy systems research and technology.......	9,600	11,200	11,200	11,900	10-12
Nuclear energy research and technology.............	1,200	---	---	---	10-13
High power lasers and energetics research and technology....................................	6,500	6,700	6,700	6,800	10-14
Entry research and technology....................	6,305	5,800	5,800	6,100	10-15
Total...	65,505	71,700	71,795	77,100	

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Materials Research and Technology................	7,100	7,500	7,500	7,800

OBJECTIVES AND STATUS:

The objective is to provide advanced materials technology for the development of efficient, economical structural materials, lubricants, seals, and thermal protection materials for advanced space power and transportation systems, space structures, orbiting spacecraft and planetary probes.

Most superalloys with potential for use in space power systems are significantly degraded during long vacuum exposure at high temperatures. The maximum use temperature, therefore, is about 800°C. Some advanced alloys offer potential for use at higher temperatures. Studies of adhesion, friction, and wear are continuing. Boron/aluminum composites nave been manufactured and are undergoing evaluation. Advanced seals and lubricants have been designed and are also being evaluated. Several heat shield materials have been developed and are being evaluated for application to advanced space transportation systems.

BASIS OF FY 1980 ESTIMATE:

Basic research activities in FY 1980 will include corrosion, chemisorption, catalysis, hydrogen embrittlement, fiber-matrix interface properties, and lifetime prediction in elastomeric systems. An improved understanding of these phenomena and processes will provide the foundation for improving performance of aerospace materials. In FY 1980, increased attention will be given to the effect of the space environment of the properties of composite materials. Materials which have good long-term resistance to space radiation will be identified. The upper use temperature for commercially available superalloys in vacuun will also be determined. Liquid and solid lubricants will be studied for their stability at high temperatures and in vacuum. High-pressure seal concepts will be evaluated in a simulated turbopump. Studies will continue to identify the most efficient heat pipe materials, working fluids, designs and processing methods to produce economical heat pipes.

Thermal protection concepts and materials are being evaluated for the protection of re-entry vehicles and planetary probes. In FY 1980, emphasis will be on obtaining better understanding of the creep of high-temperature alloys for hot structures. For insulating heat shields, the emphasis will be on evaluating refractory fibers capable of withstanding teinperatures as high as 3500°F. Heat shield materials for planetary and solar probes will also be developed and tested to evaluate their performance.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Structures Research and Technology.................	6,000	7,200	7,200	7,700

OBJECTIVES AND STATUS:

The objectives of this program are to provide advancemznts in current structural technology needed to promote improved performance, durability and economy in future space systems design and to develop advanced structural concepts, design, and qualification procedures to enable development of new systems with operational requirements well beyond the current state of technology.

The "Shock Spectra" method of dynamic loads prediction being developed for use in the initial design stages of payloads has been successfully verified using the Viking spacecraft flight data. Deployable platform truss configuration studies have been completed and a ground test program to verify deployment dynamics predictions is in progress. Plans have been completed for experimental evaluation of a concept for joint configuration and assembly of erectable platforms.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the research and technology efforts will continue to evaluate selected structural concepts for deployable and erectable space systems and to establish design and qualification procedures required to meet possible future mission requirements.

In the area of design methods, emphases will be on improved computational efficiency and continued development of structural modeling and analysis methods to meet the design needs of future space systems, including nonlinear behavior due to large deformations and nonisotropic composite material application, fatigue life of advanced metallic and composite materials, and structural/controls dynamic interactions.

In dynamics, the focus will include the adaptation of payload loads and vibroacoustic design methods to shuttle-type vehicles and the development of concepts for control of structural dynamic modes of space systems and improved methods of dynamic model testing.

The high-temperature structures effort will continue development of metallic structures for Earth entry vehicles capable of withstanding temperature; of 1500°F or more, metallic multiwall thermal protection systems, and validated thermal stress prediction methods.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Sensing and Detection Research and Technology	4,400	5,950	4,895	5,400

OBJECTIVES AND STATUS:

The objectives of the Sensing and Detection Research and Technology program are to provide advanced concepts, technologies and components to improve the data acquisition capabilities of future applications snd science missions and to ensure their long-term reliability.

The attainment and testing of ultrasensitive silicon charge-coupled device arrays with up to 640,000 sensing elements has resulted in their acceptance for the cameras to be used on the Space Telescope and Galileo missions.

The first linear array with infrared capability out to 5 micrometers has been developed and tested. In addition, millimeter and submillimeter wave solid-state components have been developed for radiometric measurements related to severe storm predictions and pollution detection.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $55 thousand is a result of rebalancing funding between the Sensing and Detection and the Guidance and Control Research and Technology Base efforts.

BASIS OF FY 1980 ESTIMATE:

New technologies are being investigated to improve the observational capabilities of sensing systems. In FY 1980, the spectral range of terrestrial images will be extended to the middle infrared region in order to map the thermal variations of the Earth's surface. For the far infrared region, charge-coupled devices will be developed and evaluated for measuring remote star fields. Near infrdred devices will be developed for observing planetary and terrestrial surface geochemical characteristics.

Lasers and electro-optical systems are being developed for acquiring specific data relsted to terrestrial and atmospheric properties. In FY 1930, the reliability of solid-state tunable laser diodes will be emphasized to assure their long-life performance for long-duration space missions. For measuring geodetic changes due to small crustal motions of the Earth, a high-pulse rate, high-energy-per-pulse lasing system will be developed to accomplish highly accurate ranging from a low orbit space platEorm to passive ground-based retroreflector targets.

Microwave components, technologies, and systems are being developed to achieve a near all-weather 24-hours-a-day sensing capability from potential future space platforms. In FY 1980, linear arrays of small radiometers will be developed to achieve spatial resolutions as low as 1 kilometer. Submillimeter wave components will be developed for frequencies as high as 1 terahertz in order to monitor stratospheric constituents that are involved in the ozone chemistry cycle. Millimeter wave components will be developed for measuring the Earth's environmental parameters such as water vapor, temperature, precipitation and wind speed.

TO ensure the reliable operation of sensor components and related electronic systems, failure mechanisms are being investigated in order to determine the causes of breakdowns and to formulate guidelines for minimizing failures. In FY 1980, emphasis will be placed on chemical and electrical evaluations of charge-coupled device structures, and semiconductor structures.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Guidance and Control Research and Technology........	3,500	3,850	4,000	4,300

OBJECTIVES AND STATUS:

The objective of this program is to develop components and techniques which will lower the costs and improve the performance of spacecraft attitude control systems, provide precise pointing of experiments, improve the accuracy of space navigation, and permit autonomous operation of spacecraft, robot vehicles operations and experiments in space, and supporting ground activities.

The fabrication of the engineering model hardware for the Annular Suspension and Pointing Systems design was completed and assembly and test begun; the Feature Identification and Location Experiment capability was verified by ground field tests, and the experiment will be conducted on a Shuttle orbital flight test; the Extended Life Attitude Control System effort was completed, and laboratory tests demonstrated that use of a solid-state star tracker yielded a factor of four improvement in accuracy over the current star tracker; and an advanced Fiber Optics Rotation Sensor was constructed and tested, further verifying the potential of this approach. In the automated operations area, the Optical Navigation experiments, using Viking, were completed; an Automated Optical Navigation configuration design was selected for development; and work was initiated in automatic image classification using Viking images.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $150 thousand reflects relatively unanticipated increases contractor and in-house costs, as well as the balancing of funding among the other disciplines within the Research and Technology Base.

BASIS OF FY 1980 ESTIMATE:

Precision pointing and control research emphasizes new concepts and components which promise reduced costs and increased mission capability. In FY 1980, development of concepts and technologies needed for control of flexible space structures will be emphasized. Development will continue on the design of an engineering model of a fiber optics rotation sensor with no moving parts that promises to provide long life, high sensitivity and low cost. Fabrication and test of precision experiment pointing and tracking system design for planetary applications will be completed. Techniques will be developed for noncontacted signal and power transfer for advanced experiment pointing systems to realize their full potential.

On-board navigation techniques are being developed to reduce costs and increase the scientific return for both Earth orbital and planetary missions. In FY 1980, an automated navigation system relying on on-board optical measurements will be implemented using a ground computer, and the system will be readied for flight use. An advanced configuration of the Feature Identification and Location Experiment will be completed, and the video landmark tracker approach to the next step will be defined.

During FY 1980, work will be expanded in developing techniques for applying machine intelligence to NASA's space program to increase productivity and reduce costs. Laboratory demonstrations will be conducted using automated manipulator technology for assembling space structures. Techniques for semiautonomous mission operations using "high level" ground commands, instead of detailed step-by-step program instructions to the spacecraft, will be demonstrated in the laboratory. Using an advanced automated problem-solver, a learning and error-correcting system will be developed and demonstrated. University studies on developing new robotic and machine intelligence techniques will be continued.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Data Reduction and Distribution Research and Technology	6,500	8,300	8,300	9,700

OBJECTIVES AND STATUS:

The objective of the Data Reduction and Distribution Research and Technology program is to provide advanced concepts, components and techniques which will improve the efficiency and reduce the cost of data handling and information extraction processes for experimental and operational space missions of the future.

During FY 1979, definition of improved data handling system concepts will be completed, a distributed data system architecture will be breadboarded, and development of improved support tools for flight software generation will be initiated. Development of a ground-based synthetic aperture radar data processor will continue, and an engineering model multispectral data processor will be assembled. A three-channel data editor using integrated optics will be assembled and tested.

In addition, an X-band solid-state transmitter will be field tested. Developmental low-noise receivers and phased-array antennas for Ku-band operation will be acquired and evaluated. Design specifications for an X-band transponder will be completed and a high data-rate fiber-optic link will be acquired for test and evaluation.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, a simulated end-to-end data system will be established and parametric studies will be conducted to optimize data handling efficiency and cost. Large scale integrated circuit components for a distributed architecture data system will be assembled and tested. Development of software support tools will continue, with emphasis on microprocessor software requirements.

A developmental synthetic aperature radar processor will be assembled and evaluated. Performance of the engineering model multispectral data processor will be tested and required design improvements initiated. High-density interconnection techniques to provide three-dimensional packaging of large scale integrated circuits will be investigated.

An advanced data processor concept combining surface acoustic wave and charge-coupled device technologies will be breadboarded, and high-density "bubble domain" memory devices employing "lattice-file" structures will be fabricated and evaluated.

Cold cathodes to improve the operating life of high-power traveling wave tubes will be evaluated. Work on solid-state 20 Gregahertz (GH_z) power amplifiers and 30 GH_z low-noise receivers will be initiated. Fabrication of an engineering model X-band transponder will begin and testing of a one gigabit/second fiber optic data link will be completed.

Development of custom large scale integrated circuit technology will continue with emphasis on computer aided techniques for design, fabrication and test.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Chemical Propulsion Research and Technology.........	8,100	9,200	9,200	9,900

OBJECTIVES AND STATUS:

The objective of this program is to advance the technology of high-thrust chemical propulsion systems in order to achieve significant reduction in the development, production and operations costs and to improve the performance capability of future space transportation vehicles and long-life spacecraft systems.

Significant progress has been made during the past year, both in advanced space transportation system propulsion and in long-life spacecraft systems. High-pressure pumps for oxygen-hydrogen engines applicable to orbital transfer vehicles have demonstrated design performance. Carbon/composite thrust chambers for a fluorine-hydrazine planetary obriter propulsion system have demonstrated successful operations at 3000 to 4000°F.

BASIS OF N 1980 ESTIMATE:

Advanced high-performance reusable chemical propulsion efforts will provide the technology for future space transportation systems, including small orbital transfer vehicles and advanced Earth-to-orbit vehicles. Technology for small oxygen-hydrogen systems demonstrating long service life is being completed. In FY 1980, the technology for small oxygen-hydrogen engines will be directed toward evaluating engine concepts designed for very low thrust operations. Systems to be considered will include single engines, designed for both high thrust and low thrust, and engines designed for low-thrust operation only. Research and technology on high-density fuel engines for advanced Earth-to-orbit vehicles will continue in the areas of simplified servicing techniques and component designs for long service life, combustion, heat transfer and cooling, and expansion nozzle configurations designed to maximize specific impulse over a variety of engine operating conditions and a1titudes.

Long-life spacecraft propulsion technology activities are directed toward systems designed to operate reliably over long periods of time, up to 10 years in space, without benefit of repair or refurbishment. These research and technology efforts include planetary retro-propulsion, deorbit, atmospheric entry, landing, and launch propulsion systems, as well as spacecraft auxiliary propulsion. Components developed will be available for assembly into a complete space-storable fluorine-hydrazine planetary retro-propulsion system under the Propulsion and Power Systems Technology program. Work will also continue in the technology areas of high-performance, heat-sterilizable solid propellants for planetary deorbit and surface-to-orbit launch systems.

Basic research will be continued to expand understanding of the chemical and physical processes that occur in rocket propulsion systems. The search for advanced concepts that will provide a new level of capability beyond conventional chemical propulsion systems will also continue. In FY 1980, the efforts will include continuation of combustion studies, exhaust plume definition and analysis of effects, performance prediction techniques, solid propellant polymers and viscoelastic properties, behavior of fluids in a low-gravity environment, and laser propulsion feasibility studies.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Electric Propulsion Research and Technology	6,300	7,000	7,000	7,500

OBJECTIVE AND STATUS:

The objective of this program is to provide the research and technology for the low-thrust, high-specific-impulse electric propulsion systems needed for advanced capabilities in near-Earth and planetary missions.

Design and fabrication efforts for a building-block primary propulsion thrust model are on schedule. In addition, work continues on auxiliary thruster flight test hardware.

BASIS OF FY 1980 ESTIMATE:

In the auxiliary electric propulsion area, an endurance test of a one-millipound thrust system will continue during FY 1980. The technology effort in support of an ion thruster flight test on a Shuttle-launched Air Force space test program satellite will be completed. A preliminary study of the propulsion requirements for future space systems will also be completed.

Resources in the primary electric propulsion program are directed toward completing the Solar Electric Propulsion technology readiness effort in FY 1980. The activity includes a multiple thruster mission profile life test and an endurance test of an engineering model thrust module. During FY 1980, work will also be continued on the development of technology for extending thruster performance over a broader range of specific impulse, thrust, and power.

Basic technology efforts will continue to support the auxiliary and primary electric propulsion efforts by providing a better understanding of the physical processes that limit life and efficiency. In FY 1980, studies will continue to evaluate critical technologies of advanced propulsion concepts such as the mass driver and the magnetoplasmadynamic accelerator. In addition applications of ion beam technology to other than propulsion uses will continue to be explored.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Space Energy Systems Research and Technology	9,600	11,200	11,200	11,900

OBJECTIVES AND STATUS:

The objective of this program is to provide the technology basis for future space power systems needed for use in-near-Earth space and in the exploration of the solar system.

A major accomplishment that occurred during this past year was the successful ground extension and retraction tests of a 12.5 kilowatt, 66 watts per kilogram solar electric power array. This array is being evaluated as the technology basis for a number of anticipated future mission needs such as Shuttle power augmentation and electrically propelled spacecraft. In other areas, advances were made toward solar cells with increased efficiency and tolerance to the radiation ervironment, as well as establishing the manufacturing feasibility of cells with three times the power output per unit mass of current flight technology cells. Fuel cell elements capable of sharing reactants and tankage with rocket engines were demonstrated. In addition, a new transistor capable of handling power levels six times greater than previously possible was demonstrated.

BASIS OF 1980 ESTIMATE:

Photovoltaic research and technology will continue to seek advances in solar cells; the covering, interconnecting, and supporting these cells into modules; and arrays. In the cell area, focus will be on incorporating a variety of advances in efficiency, radiation immunity, and structure into the thin (approximately fifty microns) silicon solar cell. Work on alternative materials to silicon will also be pursued, as will advances in understanding the radiation damage repair prospects of thermal annealing. In the module area, research on encapsulants, adhesives, substrates, and welding will continue, with emphasis on thin cell cover systems. In the array area, both lightweight and low-cost techniques will continue to be explored.

Research aimed at doubling the life of the high energy density Nickel-Cadmium battery by 1981 will continue. Work recently initiated to produce high-capacity energy storage required for future high power missions will continue. Emphasis will be placed on the fuel cell electrolyzer and high-capacity battery cells. In addition, work toward very high energy density storage systems, based on sodium and lithium, will continue.

In the thermal conversion area, work toward promising high-efficiency (15 percent) thermionic and thermoelectric converters will emphasize fabrication of a half length heat pipe/thermionic converter system. Life testing of the 10-kilowatt Brayton cycle rotating unit is also expected to be completed in FY 1980.

As a result of cooperative efforts with the Air Force, design criteria for protecting systems from the effects of spacecraft charging at high orbital altitudes will be established. In addition, analytical and experimental assessments of the interaction between high voltage surfaces and the surrounding space plasma will continue.

In the area of power management and distribution, work will continue on high-power switchgear, high-frequency (50 kilohertz) converters, and automated power management. Initial evaluation of automated management of planetary solar array/battery systems will be completed in FY 1980.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Nuclear energy Research and Technology	1,Z00	---	---	---

OBJECTIVES AND STATUS:

The Nuclear Energy Research and Technology program was concluded in FY 1978. In prior fiscal years, gaseous fuel reactors have been the subject of research and engineering investigations into the feasibility of advanced concepts for space nuclear power and propulsion. The major focus of this research has been a series of proof-of-principle experiments conducted for NASA by the Los Alamos Scientific Laboratory. The funding provided in FY 1978 carried this series to a logical conclusion through the accomplishment of goals established at the start of the program. With the success of these tests, this research effort on gaseous fuel reactors has proven the essential capability of the concept to produce power in a configuration that could be scaled to high performance levels.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
High Power Lasers and Energetic Research and Technology	6,500	6,700	6,700	6,800

OBJECTIVES AND STATUS:

The High Power Lasers and Energetics Research and Technology program provides, through basic research and experimental engineering, major technology advances in the generation, conversion, and transmission of energy for future capabilities in space. It also supports research on cryogenic systems required to operate sensors and other equipment in space.

Recent progress includes the demonstration of phase-locking of high-power lasers. This achievement has significance in the scaling of laser systems to extremely high power levels and represents the first-reported observation of a conducting (metallic) state in xenon. In addition, precisely-tuned short-wavelength laser, suitable as a remote-sensing instrument which can be carried in balloons, aircraft or spacecraft has been developed. The operation of a cryogenic cooler unit, based on helium-3 and capable of use in the zero-gravity environment of space flight has also been accomplished.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, magnetics and cryophysics research will concentrate on means to extend the operating durations of coolers for space missions involving both mechanical devices and superfluid helium. Emphasis will also be placed on atomic and metallic hydrogen as potentially new concepts for energy storage.

In fundamental photonics, basic research will focus on the emission and absorption of radiation from all states of matter in support of power generation, propulsion, laser, space environment, and atmospheric physics. Areas of continuing emphasis are the direct conversion of fission fragment energy into coherent light, the coupling of electron beams with laser beams, and the chemistry and physics of high-power laser beams in remote sensing of terrestrial and planetary atmospheres and surfaces. In addition, experimental studies of advanced solar energy conversion will continue.

FY 1980 high-power laser systems research will continue investigations of the conversion of laser energy to electrical energy or directly to propulsive forces.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Entry Research and Technology	6,305	5,800	5,800	6,100

OBJECTIVES AND STATUS:

The objective of this program is to improve the understanding of the aerothermodynamic, gasdynamic and flight mechanic problems of spacecraft designed for Earth orbital missions and planetary exploration. This knowledge will be used to improve the safety, reliability and efficiency of these spacecraft.

In the area of Shuttle aerothermodynamics, and analysis of all available aerodynamics data obtained on the Orbiter was completed and the subsonic, transonic, supersonic, and hypersonic/viscous sections of the Orbiter Aerodynamic Design Data Book was updated. In addition, technology assessment studies completed in the past year have indicated that for advanced heavy-lift single-stage-to-orbit vehicles, the far aft center of gravity location (75 percent of length) is a major design issue that must be addressed and solved before the advantages associated with advanced technology can be realized. In the area of planetary entry probes, the capability has been developed to calculate the turbulent flow field about a massively ablating sphere cone entry body during descent through the atmosphere of Jupiter. In the flight data analysis effort, several experiments to be conducted on the Shuttle Orbiter are under construction. These experiments will provide research-quality data for use in evaluating theoretical and experimental methods.

BASIS OF FY 1980 ESTIMATE:

In the area of advanced Earth-orbital transportation aerothermodynamics, the objective is the development of a fundamental understanding of the phenomena involved and approaches to future vehicle designs. These efforts are aimed at improving performance and reliability and reducing costs for a variety of potential space missions. In FY 1980, continued emphasis will be placed on development of theory, advanced computational methods, and computer codes for predicting vehicle flow fields and performance; development of improved ground-based experimental techniques, instrumentation and simulation capability; advanced vehicle design integration capability; and the development of an aerothermodynamic data base from ground facility and flight investigation to support future advanced vehicles.

The planetary probe technology effort provides the aerothermodynamic base which supports current and future scientific missions to study the atmospheres of Venus, Mars, the outer planets and certain of their satellites. This technology base supports the aerothermodynamic design, development, and verification of planetary probe configurations and provides the flight mechanics data in support of the atmospheric reconstruction experiments. In FY 1980, theoretical and experimental efforts will be continued in the areas of shock-layer radiation, ablation product radiation and absorption, highly blown shock-layer, probe flight mechanics, and mass loss and shape change. These studies will be pursued to develop a data base to minimize planetary mission costs, to maximize the scientific returns, and to insure a high probability of mission success.

The space shuttle aerothermodynamic effort in FY 1980 will provide support in the form of ground-based facility analysis of test results.

The aerothermodynamic flight data analysis effort will use the Orbiter Experiment flight data to understand phenomena which cannot be simulated in ground facilities, to develop techniques for extrapolating ground facility results to flight conditions, and to verify analytical and computational prediction techniques. In FY 1980, analysis techniques and associated software will be developed and the data base will be defined in preparation for analysis of flight data.

SYSTEMS STUDIES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Systems Studies..	2,000	2,000	2,000	2,200

OBJECTIVES AND STATUS:

The objectives of System Studies are to identify and evaluate the technology requirements of advanced system candidates; to investigate future space mission alternatives; to assess the effects of technology advances; and to provide a data base to support technology program selection and program planning. Studies will continue to examine: the development of future program technology needs; subsequent determination of detailed technology requirements and alternative solutions for satisfying needs and requirements.

During FY 1979, studies have been extended to develop technology requirements for a space-based radio astronomy antenna; a space-based mission for detecting planetary systems beyond our solar system; and the readiness of radar technology for the Venus Orbiting Imaging Radar and potential ocean condition monitoring missions. Studies are continuing to investigate the possible utilization of nonterrestrial resources for space applications. Studies of future concepts for global service platforms to meet the total information collection and transfer needs of the 1990's are being continued. Platform studies have been initiated and low-thrust orbital transfer technology options are being developed. Technology requirements for multipurpose platforms, including structures, antenna and power, are being evaluated.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 efforts will continue to focus on the themes of technology for future space applications, explorations and transportation.

A continuing study emphasis will be placed on technology for Earth applications. This multi-Center activity, which developed baseline configurations for the advanced g obal services concept, w 11 continue to conduct parametric trade studies of system options. Space applications theme studies dealing with advanced concepts and technologies will be continued and/or initiated.

Exploration technologies study programs will examine integrated Earth orbiting platform systems for scientific missions. Critical technology issues associated with planetary sample return missions will be examined.

Transportation studies will continue to focus on orbital transfer technology issues and to formulate specific recommendations for technology programs to respond to total space transportation system needs and opportunities.

Utilization of space studies will be directed at defining experimentation in ground- and space-based facilities to gain a better understanding of the nonterrestrial materials options.

Advanced concept development studies will continue to serve as a basis for modeling future technology needs and requirements.

Technology-specific studies will catalogue and rank available, planned and forecasted technology from sources within and outside NASA. Continuing studies of technology seek to rank options andtodevelop strategies for the the attainment of long-range goals through application to near-term missions. Special study emphasis will be given to key technology issues, such as automation, space structures and materials, cryogenic systems, reusable propulsion, end-to-end data management and kilowatt/megawatt power sources for the purpose of defining future program options.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Electronic systems technology........................	1,000	3,200	3,200	9,900	RD 10-18
Materials and structures systems technology...........	4,000	3,800	3,800	5,200	RD 10-19
Propulsion and power systems technology...............	800	900	900	900	RD 10-20
Total....	5,800	7,900	7,900	16,000	

Electronic systems technology........................	1,000	3,200	3,200	9,900

OBJECTIVES AND STATUS:

The objective of this program is to integrate advanced electronic devices or system concepts developed in the Research and Technology Base with supporting technology to demonstrate and validate improved performance, increased reliability and reduced costs of space electronics and data handling systems.

In FY 1979, the second phase of the NASA End-to-End Data Systems (NEEDS) program was initiated. The first phase, which was carried out in the Research and Technology Base program; focused on the development of critical component technologies and system concepts to meet the high data-rate processing demands of future space missions. The second phase is to develop and evaluate engineering subsystem and system hardware required to provide near real-time processing of space-derived data and demonstrate increased data-handling capability at reduced costs. During FY 1979, system parameters will be established; design specifications for major hardware subsystems will be developed; and external and internal system interfaces will be defined. Major subsystems include an Information-Adaptive Data System, Modular Data Transport System, Massively Parallel Processor, Archival Mass Memory and a Data Base Management System.

BASIS OF FY 1980 ESTIMATES:

The principal activity in the second phase of the NEEDS program during FY 1980 will be the development of system and subsystem hardware. Major subsystems will be procured through contractual efforts with industry. This activity will extend into the FY 1981 timeframe and will be supplemented by in-house activities to develop necessary software and system interfaces. Subsequent efforts will integrate the major elements into a systems breadboard that will be tested and validated in representative data management applications.

A key activity in FY 1980 will be the initiation of systems technology efforts for advanced space communications--satellite communications technology. This activity is to develop and evaluate specific hardware components required to support advanced communication systems developments in Space Applications. These complementary activities are an important step toward maintaining the Nation's leadership in space-base communications technology. FY 1980 efforts will focus on the development of multi-beam antenna feeds and switches, efficient power amplifiers, low-noise mixers, and on-board processors for signal routing and storage. Breadboard hardware configurations will be built and tested. In addition, performance characteristics will be assessed and design specifications for system applications will be prepared. Propagation modeling and ground terminal technology development will be added to complete and integrated technology program,

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Materials and structures systems technology............	4,000	3,800	3,800	5,200

OBJECTIVES AND STATUS:

The objectives of this program are to expand the materials and structures technologies developed in the Research and Technology Base programand to verify their validityby extensive test of large scale systems to facilitate timely use in space systems design.

In the Composites for Advanced Space Transportation Systems (CASTS) program, four polyimide matrix systems has been selected, and fabrication technology developments are under contract for these materials. Two high-temperature adhesives have been identified for this 600° Fahrenheit application. In the Space Structures Systems Technology efforts, future space systems have been defined; critical technology requirements have been identified; and concepts for deployable and erectable reflectors and platforms are being developed.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, emphasis will be given to the fundamentals associated with graphite/polyimide panels to determine strength and life at 600° Fahrenheit.

The objective of the space structures systems technology activity is to provide the enabling technology in structures, materials, assembly, and controls to support future design of space systems. In FY 1980, technology verification of structural elements, components, and assembly methods for platforms and reflectors will be continued. Requirements for control of space structures will be defined, and development of control systems technology will be initiated.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propulsion and power systems technology...............	800	900	900	900

OBJECTIVES AND STATUS:

The objective of this program is to demonstrate technology readiness of advanced space propulsion and power systems by conducting tests of complete systems assembled from advanced technology components already demonstrated under the Research and Technology Base. The system/level tests are designed to evaluate component interactions and to demonstrate overall system performance and operation, under both transient and steady-state operating conditions.

The program to advance the technology of high-energy, space-storable propulsion systems has encountered some minor problems in engine cooling. Some component procurements have been delayed in order to focus attention on the cooling problems.

BASIS OF FY 1980 ESTIMATE:

The goal of the Long Life Chemical Propulsion Systems activity is to design, fabricate, assemble, and test a near flight-weight advanced planetary orbiter spacecraft propulsion system, utilizing high-performance space-storable fluorine-hydrazine propellants under simulated space vacuum conditions. The objective is to demonstrate overall propulsion system performance and operation, and establish handling, safety and launch operation procedures. In FY 1980, all component and subsystem design verification testing efforts will be completed and final component procurements initiated, including the flight-weight fluorine-hydrazine thrust chamber assembly.

BASIS OF FUND REOUIREMENTS:

EXPERIMENTAL PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space technology Shuttle/Spacelab payloads...........	15,395	17,700	16,605	18,100
Space transportation system operations...............	(---)	(2,600)	(2,600)	(4,800)

OBJECTIVES AND STATUS:

The objective of this program is to provide the capability to extend research and technology programs into space when that unique environment is essential to the progress of a program, when an in-space test is cost effective, when an in-space verification will accelerate the utilization of advanced technology, or when there exists the opportunity to exploit the operation of a space system for research. The program provides for the definition, development, and management of experiments, payloads and facilities which capitalize on the capabilities of the Space Shuttle, the Spacelab, and free-flying spacecraft.

In FY 1979 the ion engine experiment, the only effort in the Free-Flying Payload activity, will be delivered to the United States Air Force for integration with its Teal Ruby Satellite.

The integration of experiments to be conducted on Shuttle/Spacelab missions has been delayed consistent with the changes in the schedule. The experiment hardware development schedules are being maintained to avoid stretchout-driven overruns.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $1,095 thousand reflects the Space Research and Technology portion of the Congressional general reduction in NASA's Research and Development appropriations request.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the Long Duration Exposure Facility (LDEF) and the 35 experiments involving 70 investigators will be integrated. These experiments were selected from proposals submitted in response to the first LDEF Announcement of Opportunity.

In FY 1980, experiments will be conducted during the Shuttle orbital flight test missions. The Spacelab 1 and 2 experiments will be delivered to the integration site, The Solar Electric Propulsion solar array demonstration hardware will complete pre-flight tests and will be delivered for integration with the assigned pallet. Experiments for subsequent Spacelab missions are being phased to assure their continued compatibility with the Space Research and Technology Base efforts. In FY 1980, development of critical high priority experiments such as cryogenic management, propulsion contamination effects, and solar cell performance verification will be continued to assure their timely application to future program requirements.

The Orbiter Experiments activity will include the core experiments, using the Shuttle capabilities as an advanced research vehicle to conduct aerothermodynamics investigations. The windward temperature experiment, utilizing the NASA C-141 telescope facility, will be used during selected OFT returns. The Aerodynamic Coefficient Identification Package will be flown during the orbital flight test missions to collect data. Two thermal protection tile experiments will be completed, tested and delivered to the Kennedy Space Center. In addition, the hardware for the leeside heating experiment and the improved air data system packages will be completed.

BASIS OF FY 1980 FUNDING REOUIREMENTS:

STANDARDS AND PRACTICES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Standards and practices............................	9,000	9,000	9,000	3,000

OBJECTIVES AND STATUS:

The Standards and Practices Program provides for approaches to minimize the costs of NASA projects by encouraging the use of space-qualified equipment on multiple missions, product improvement through component upgrading, and on improvement of program practices, concentrating on such areas as specification, testing and flight project analysis.

These objectives are being accomplished in two functional areas: standard equipment and program practices. Within the standard equipment area, standards fall into six disciplines: (1) electrical power; (2) communications and data handling; (3) auxiliary propulsion; (4) stabilization, guidance and control; (5) ground support equipment; and (6) payload instrumentation. Those items which could meet the requirements of multiple users are identified by agency-wide panels, which define the requirements and interfaces of suitable hardware.

Program practices activities involve the review and evaluation of techniques associated with the major cost elements of hardware acquisition, development, integration, and project operations. In addition, efforts are underway to establish a readily accessible computer listing of available space-qualified hardware.

Through FY 1979, approximately thirty components will have been declared as standard items for use on NASA missions. These standards include items such as tape recorders, flight computers, transponders, igniters, batteries, power regulators, thrusters, test sets, star trackers, reaction wheels, inertial reference units, data handling and command components, cameras, and articulation systems. Fourteen of these standards have completed development and qualification and are now available for flight project use. During the past year, the practices activity reviewed major NASA flight projects to determine the practices used, continued development of engineering standards for STS payloads, and participated in the development of an automated procurement system.

With the completion of a significant number of standardization efforts, the Standards and Practices program in FY 1980 will be redirected to focus more on maintenance and product improvement of existing standards, while placing emphasis on program practices.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget request places emphasis on product improvement of developed standard hardware, including the upgrading and technological enhancement of selected components. Development efforts will be completed onnineadditional components. Increased emphasis will be placed on program practices, with major thrusts in the areas of specifications, test, and flight project analysis.

ENERGY
TECHNOLOGY

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — ENERGY TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Energy technology	7,500	3,000	5,000	3,000
Distribution of Program Amount by Installation:				
Johnson Space Center	875	---	900	---
Marshall Space Flight Center	1,165	---	1,500	850
Jet Propulsion Laboratory	1,551	1,400	1,200	1,050
Ames Research Center	140	---	---	---
Lewis Research Center	1,409	1,600	1,400	1,100
Headquarters	2,360	---	---	---
Total	7,500	3,000	5,000	3,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — ENERGY TECHNOLOGY

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of this program is to relate NASA's aeronautical and space technologies, engineering, scientific, and managerial expertise, and existing facilities capabilities to the research and development needs of the Department of Energy and other agencies. These activities contribute to the search for solutions to energy problems on Earth. The Energy Technology activity accomplishes the program objective through investigations of the potential application of NASA capabilities to energy-related problems and development of plans for reimbursable support for work which NASA could appropriately perform when the investigations are sufficiently mature. These investigations form a basis for Department of Energy decisions concerning programs in critical energy R&D areas.

The success of this approach is borne out by the fact that in FY 1979 NASA's energy-related reimbursable efforts for the Department of Energy will total approximately $160 million. The Department of Energy has assigned to NASA expanded project responsibilities in such areas as Wind Energy, Low-Cost Solar Cell Arrays, Solar Heating and Cooling, Energy Storage, Solar Thermal Electric Conversion and Automotive Heat Engine Technology. In addition, reimbursable support will be initiated in FY 1979 in the Satellite Power System and Nuclear Waste Management in Space study areas.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Final Congressional action on the FY 1979 R&D budget request added $2 million for satellite power system technology work. These funds are to be used for critical technology investigations in the areas of microwave power transmission, energy conversion, power distribution and processing, and materials and controls.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, NASA's energy technology efforts will continue to focus on areas where NASA-developed expertise can be utilized. This will include investigations in: Stirling Engines, Gas Turbine Materials and Combustion Techniques, Coal Cleaning and Conversion, Cogeneration, Industrial Process Energy Conservation, and Integrated Solar Power Systems Applications.

In addition to bringing new capabilities to bear on energy problems, this work will capitalize on the experience which NASA has gained in support of the DOE in prior years.

Beginning in FY 1979, the Department of Energy budgeted for the joint DOE/NASA satellite power system studies. The funding for continuation of these joint studies in FY 1980 and subsequent years is to be included in the DOE budget request.

TRACKING AND DATA ACQUISITION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Operations..	228,584	254,200	251,600	275,800	12-4
Systems implementation............................	40,400	41,300	40,500	46,400	12-15
Advanced systems..................................	9,316	9,900	9,900	10,600	12-23
Total..	278,300	305,400	302,000	332,800	

Distribution of Program Amounts by Installation:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Goddard Space Flight Center........................	199,211	220,700	216,200	238,200
Jet Propulsion Laboratory..........................	57,626	63,600	61,300	68,800
Wallops Flight Center...	5,444	5,600	5,900	6,300
Dryden Flight Research Center...............	3,154	3,500	3,300	3,000
Headquarters.......................................	12,865	12,000	15,300	16,500
Total..	278,300	305,400	302,000	332,800

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA AQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

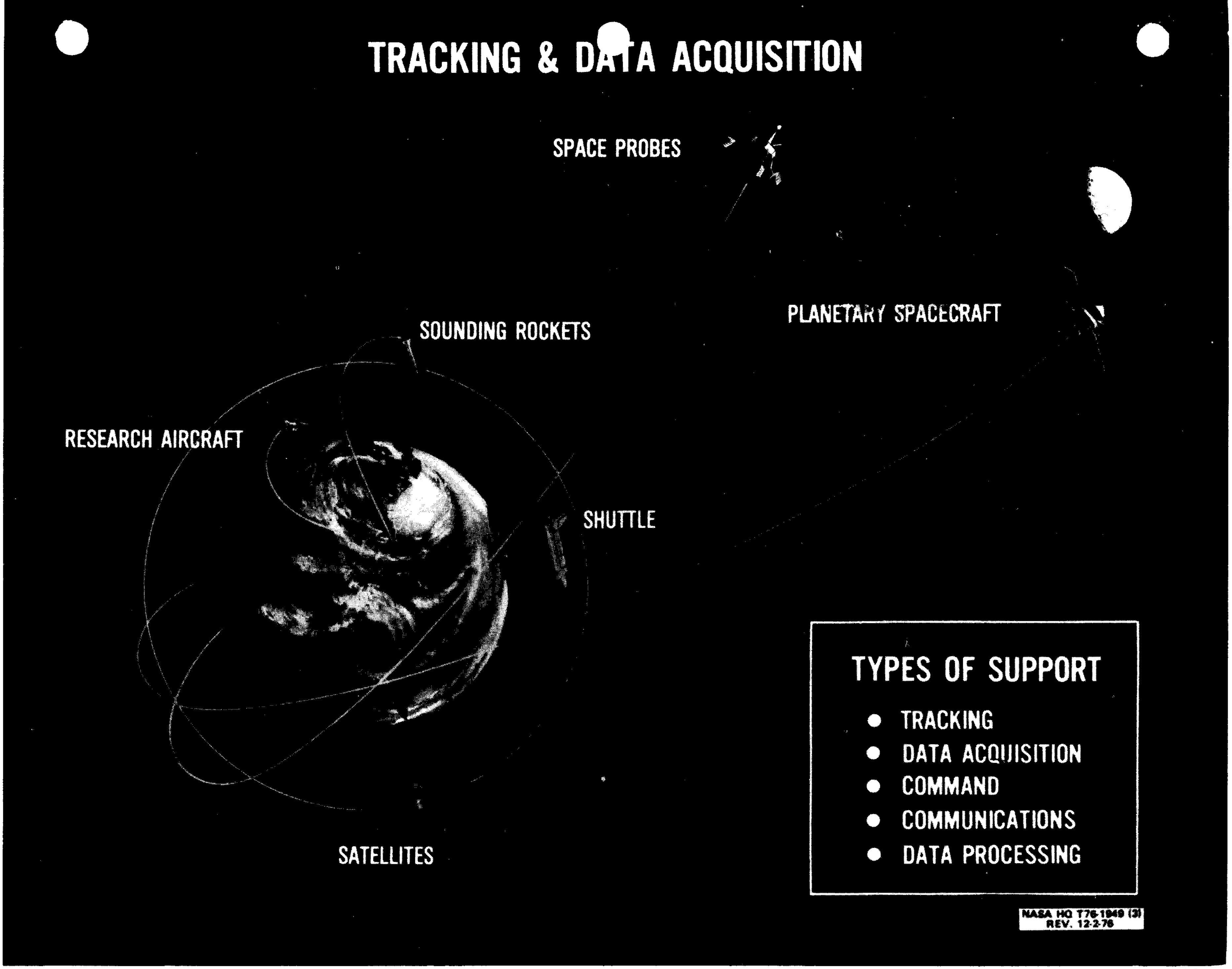
The purpose of this program is to provide vital tracking and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense, other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for: sounding rockets, research aircraft, earth orbital and suborbital missions, for lunar and planetary spacecraft, and for deep space probes as depicted in Figure 1. It also includes the support of all phases of the Space Shuttle program, from the completed Approach and Landing Tests to the upcoming Orbital Flight Tests, and the Space Transportation System operational flights.

The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and earth applications data from onboard experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) transmission of commands from ground stations to spacecraft; (e) communication with astronauts and acquisition of biomedical data on their physical condition; (f) communication of information between the various ground facilities and central control centers; and (g) processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of Shuttle missions, to insure the safety of the crew.

Tracking and acquisition of data from the space flight projects is accomplished by the use of a world-wide network of NASA ground stations. These facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft in space and control centers in the United States from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established two types of facilities to meet the needs of the two basic classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports earth orbital scientific and applications programs, and the Deep Space Network (DSN), which supports planetary and interplanetary flight missions.


TRACKING & DATA ACQUISITION
SPACE PROBES
PLANETARY SPACECRAFT
SOUNDING ROCKETS
RESEARCH AIRCRAFT
SHUTTLE
SATELLITES
TYPES OF SUPPORT
• TRACKING
• DATA ACQUISITION
• COMMAND
• COMMUNICATIONS
• DATA PROCESSING
NASA HQ T76-1949 (3)
REV. 12-2-76

Computation facilities also are provided to process into meaningful form the large amounts of scientific, applications and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities; (b) the engineering and procurement of equipment to sustain and modify the network systems to support continuing, new and changing flight project requirements; and (c) the development of advanced tracking and data acquisition systems and the investigation of advanced tracking and data acquisition techniques.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current estimate for FY 1979 is $3.4 million below the budget estimate. Of this amount, $2.4 million reflects the impact of Congressional reduction in the Tracking and Data Acquisition budget request for FY 1979. Of the $2.4 million reduction, $1.4 million was identified with support of the search for extraterrestrial intelligence (SETI) research and $1.0 million was unspecified. An additional $1.0 million reduction in the Tracking and Data Acquisition budget request for FY 1979 resulted from a $4.5 million unspecified Congressional reduction in the FY 1979 NASA Research and Development appropriations request. The allocation of the unspecified reduction is consistent with the Shuttle schedule and the early deactivation of the tracking ship, the USNS Vanguard.

BASIS OF FUND REQUIREMENTS:

OPERATIONS

The FY 1980 funding requirements are based upon a continuing support workload for an average of approximately 60 automated earth-orbiting and planetary missions. The operations funding will also provide for the pre-launch support activity required for upcoming approved missions. The increase in the FY 1980 funding request for Operations is due to two factors: (1) continuing cost escalation in all areas of Operations; and (2) support of the upcoming Shuttle Orbital Flight Tests requiring additional activity in the Spaceflight Tracking and Data Network and a significant increase in the costs .or the additional wideband communications circuits to transmit the high volume of data between the Shuttle and the ground control facilities.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	Budget Estimate	Page No.
		(Thousands of Dollars)			
Spaceflight tracking and data network.................	120,170	129,900	129,100	141,200	12-5
Deep space network..................................	46,570	49,800	49,800	55,600	12-7
Aeronautics and sounding rocket support...............	4,982	4,900	4,900	4,800	12-10
Communications......................................	27,931	37,900	34,800	39,800	12-11
Data processing.....................................	28,931	31,700	33,000	34,400	12-13
Total...	228,584	254,200	251,600	275,800	

Spaceflight Tracking and Data Network Operations......	120,170	129,900	129,100	141,200

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network is to support all NASA earth orbital space flight missions, including the Space Shuttle. The majority of these missions have near-earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer missions. In addition, the network provides launch support to NASA's automated planetary missions, as well as the spaceflight missions of other nations, commercial firms, the Department of Defense, and other United States Government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by the flight projects continues for several years.

The Spaceflight Tracking and Data Network presently consists of fourteen geographically dispersed ground stations, thirteen of which are located at remote sites and one at the Goddard Space Flight Center (GSFC), Greenbelt, Maryland. A network control center and mission control center complex are also located at the GSFC which has the field center management responsibility for the network.

These global facilities have the capability to electronically crack the spacecraft, send commands for spacecraft and experiment control purposes, receive engineering and scientific data from the spacecraft, and in the case of the astronauts, maintain voice communications for crew safety and other project related purposes. To meet the extremely precise tracking needs of NASA's Earth and Ocean Dynamics Programs, the network is supplemented by laser tracking systems capable of providing precise tracking accuracies.

In addition to the operational facility at Goddard, the thirteen land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Rosman, North Carolina; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; Quito, Ecuador; Winkfield, England; and Madrid, Spain. A transportable station is located at NASA's Dryden Flight Research Center, California, for support of the Shuttle program. Smaller transportable stations will be located at New Smyrna Beach, Florida and Bangor, Maine, for support of the early Shuttle missions. An engineering test and network system training facility at the Goddard Space Flight Center is also maintained and operated as part of the Spaceflight Tracking and Data Network.

The Spaceflight Tracking and Data Network is currently providing support for an average of nearly 50 automated applications and space sciences spacecraft. Examples of significant missions being supported include the Earth Resources Technology Satellites (Landsat-2 and 3); four Applications Technology Satellites (ATS 1, 3, 5 and 6); the Heat Capacity Mapping Mission; the Orbiting Astronomical Satellite-3; two High Energy Astronomical Observatories (HEAO-1 and 2); Atmosphere Explorer (AE-5), Nimbus 5, 6, and 7; Geodynamics Experimental Ocean Satellite (GEOS-3); the International Sun Earth Explorers (ISEE 1, 2 and 3); and the International Ultraviolet Explorer.

Upcoming missions to be supported by the network include HEAO-C, the Magnetic Field Satellite (MAGSAT), the Solar Maximum Mission, and the Space Shuttle Orbital Flight Tests. The overall spacecraft support workload of the Spaceflight Tracking and Data Network is projected to average approximately 50 spacecraft during FY 1980.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $.8 million is a net reduction resulting from allocating to Tracking and Data Acquisition $1 million of the unspecified Congressional reduction in the FY 1979 funding requirements. This is accommodated by the earlier than planned deactivation of USNS Vanguard tracking ship after a thorough review of support requirements for the Shuttle orbital flight tests. In addition there was an unanticipated increase for Skylab support, a requirement to extend operation of the Smithsonian Astrophysical Observatory laser network beyond the planned termination date and also a decline in the value of the United States dollar affecting operations overseas.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements for the Spaceflight Tracking and Data Network Operations provide for the maintenance and operation of the network and control center facilities, as well as the related logistics, network planning, scheduling, documentation, and computer programming costs associated with the around-the-clock operation of the network. Since these operations are manpower intensive the projected increase from FY 1979 to FY 1980 is due largely to continuing worldwide inflation. Some additional network support costs for the Shuttle orbital flight tests are also projected in FY 1980. It is also planned to provide a ground back-up recording capability for Landsat-3 support in the event of failure of the onboard Landsat-3 tape recorders. The operation of this capability will insure a continued flow of Landsat-3 data until Landsat-D can be launched.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Deep Space Network Operations......................	46,570	49,800	49,800	55,600

OBJECTIVES AND STATUS:

The primary function of the Deep Space Network is to support planetary and interplanetary space flight missions. The Deep Space Network provides the vital two*-way communication link by which the distant spacecraft are controlled and scientific data are acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems, software, and operational techniques that push the state-of-the-art in telecommunications.

The Deep Space Network stations are located at Goldstone, California; Canberra, Australia; and Madrid, Spain. The stations consist of one 64-meter and two 26-meter diameter antennas at each location, except at Goldstone where one of the 26-meter antennas has been expanded to 34 meters. Similar modifications are currently underway to provide the same configuration at the two overseas locations. The three locations are approximately 120° apart in longitude and permit continuous viewing of the planetary spacecraft. A centralized control center for the network is located at the Jet Propulsion Laboratory in Pasadena, California. JPL has field management for the network. Figure 2 depicts the 64-meter antenna facility complex at Canberra, Australia.

The current workload in the Deep Space Network consists of the seven on-going Pioneer spacecraft (Pioneers 6-11, and Pioneer-Venus), the three Viking spacecraft (one orbiter and two landers), the two Helios missions, and the two Voyager spacecraft. Support of these missions will continue during FY 1980 except for the Viking orbiter.

The Pioneer Venus orbiter/probe mission provided an excellent test of the Deep Space Network (DSN) capabilities when the network successfully supported simultaneously five vehicles (four probes plus the main bus) as they entered the Venusian atmosphere. Data was obtained from all five vehicles through their descent into the hot Venusian atmosphere for the entire period they were able to transmit data. The Pioneer Venus orbiter spacecraft is continuing to be supported by the DSN and returning excellent data.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Of the older Pioneer spacecraft, Pioneer 10 is already over 2.5 billion kilometers from Earth and is proceeding on a path that will take it beyond the solar system. Pioneer 10 continues to be the most distant human made object ever communicated with and each time data is received, a new communications record is established. The Pioneer 11 spacecraft, some 1.1 billion kilometers from Earth, is also being tracked during its journey to the planet Saturn which it is scheduled to fly by during the third quarter of calendar year 1979. The Pioneer 6-9 spacecraft are provided support for coverage of special events such as solar conjunction. The two Helios missions are continuing their orbit about the Sun as they gather data on the solar plasma. The three Viking spacecraft are now in an extended mission phase.

Taking advantage of a rare alignment of the outer planets Jupiter and Saturn, two Mariner-class spacecraft, Voyager 1 and 2, were launched in 1977. Preparations have been completed in the Deep Space Network to provide the necessary support for the Jupiter encounter phase which occurs in March and July 1979 for Voyager 1 and 2, respectively. As is typical of planetary missions, the two Voyager spacecraft will require support for several years during their flight to Jupter and Saturn.

The Deep Space Network facilities are also used for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources and other interstellar phenomena. During FY 1980, support of these radio astronomy experiments will continue on a non-interference basis to the planetary flight missions.

In addition to the Voyager missions, the upcoming Deep Space Network workload also includes preparation for support of the Galileo and International Solar Polar Missions. These support preparations require thorough and complex testing, training, engineering and software effort and compound the difficulty of overall support planning and execution since such preparations must be carried out at the same time that the network is supporting the extensive and continuous on-going workload described above.

BASIS OF FY 1980 ESTIMATE:

Deep Space Network operations funds provide for the contractor maintenance and operation of the network facilities, network control center, and the network support and engineering effort associated with the operation of the network. The funds requested for FY 1980 are based upon the on-going workload, including the Pioneer 6 through 11 missions and the Pioneer Venus mission, and the Voyager missions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and Sounding Rocket Support Operations....	4,982	4,900	4,900	4,800

OBJECTIVES AND STATUS:

Instrumentation systems are maintained and operated for the sounding rocket, balloon, small satellite, and aeronautical programs conducted by the Wallops Flight Center and the aeronautical flight research programs of the Dryden Flight Research Center. These instrumentation systems include general purpose tracking, telemetry, data handling, and communications systems, as well as special purpose optical equipment.

The sounding rocket program continues to be very active, with over three hundred launches last year, ranging from the smaller meteorological rockets to the larger Scout rockets. The majority of these sounding rocket launches are conducted at the Wallops Flight Center. This workload is expected to remain at approximately the same level in FY 1980. In addition to the continu'ing sounding rocket, balloon and aeronautical program activities, Wallops will provide specialized tracking, evaluation, and calibration services for the launch phases of the Shuttle orbital flight tests.

The Dryden Flight Research Center (DFRC) operates the Aerodynamics Test Range, consisting of facilities at DFRC and an uprange site at Ely, Nevada. These facilities are composed of precision radar tracking, telemetry, and communications equipments, which are used to monitor and control high performance aircraft research and development programs of both NASA and the Air Force. In the first half of 1979, NASA plans to turn the operations of the Ely site over to the Air Force for support of their programs. This action is possible due to the completion of the YF-12 flight program. Various aircraft research and technology projects are supported by the Aerodynamics Test Range. Aircraft flown in these flights include the F-111, F-104, F-15, F-8 and remote piloted vehicles including Highly Maneuverable Aircraft Technology (HiMAT). Tracking and data acquisition support of the Shuttle orbital flight tests is planned at the Dryden Flight Research Center for FY 1979 and FY 1980.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements support the sounding rocket launches and the Aerodynamics Test Range activities. The request also includes the anticipated effect of escalation and the necessary resources to support the initial Shuttle orbital flight test landings at the Dryden Flight Research Center.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Communications Operations............................	27,931	37,900	34,800	39,800

OBJECTIVES AND STATUS:

NASA's global communications network (NASCOM) interconnects by means of leased voice and data circuits the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations. Figure 3 is a pictorial representation of NASCOM.

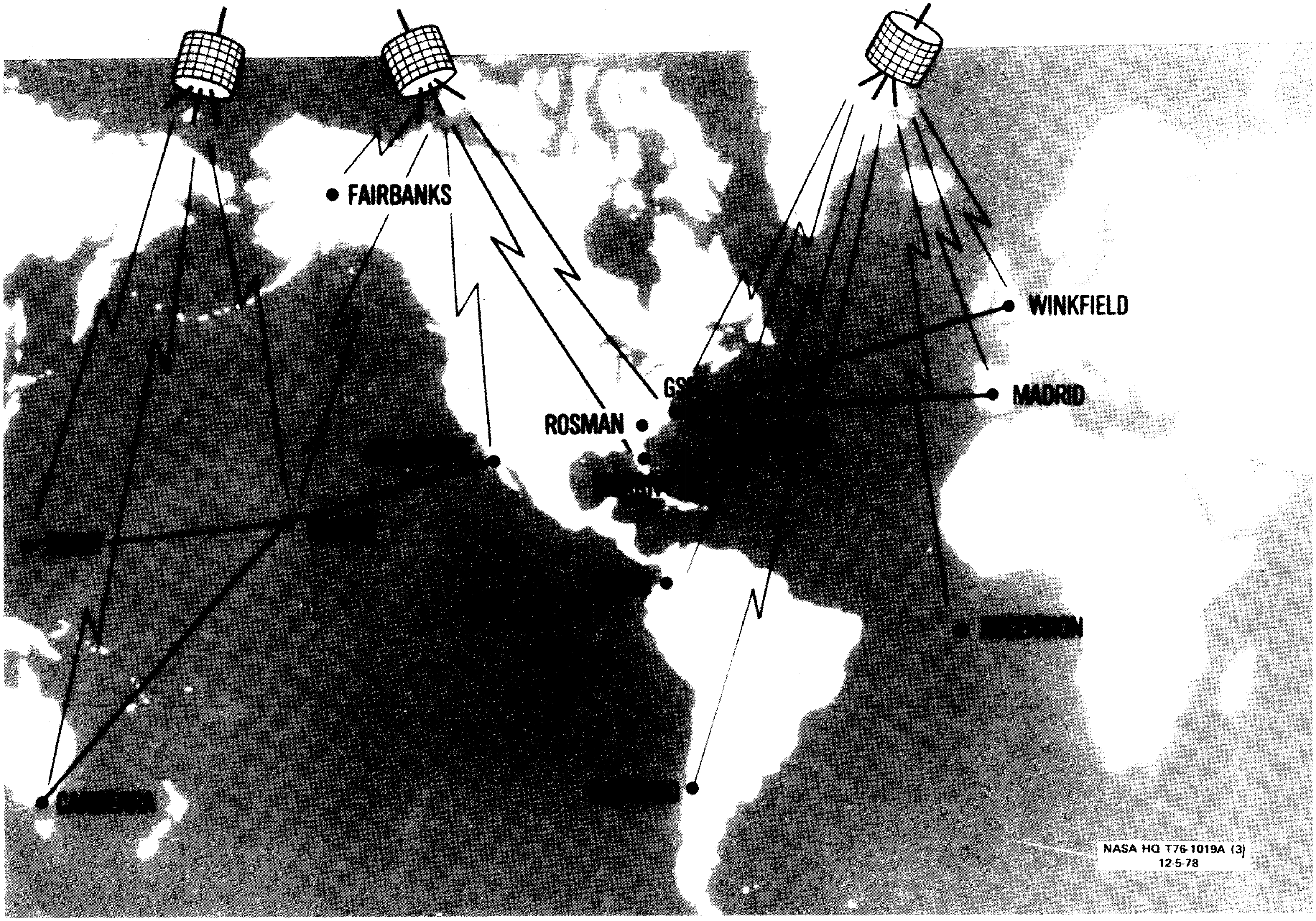
To an increasing extent, the NASA flight projects are requiring the transfer of greater amounts of data between the mission control centers and the tracking sites because of the need for real time control of the spacecraft and on-board experiments. In addition, there is a requirement to provide increasing amounts of experiment data more quickly to the users for analysis.

In order to meet high data transfer rate requirements, NASA is increasing its utilization of digital techniques in providing communications support. The availability of this technology allows for a greater amount of data to be sent over conventional communication circuits. Also, circuits capable of transferring data at increasingly higher rates are becoming available from the common carriers at reasonable costs. Consequently, the techniques of sending data directly from a spacecraft, through a tracking station without manipulation, to a mission or project control center has become economically attractive. This approach, referred to in the communications field as a "bent pipe" mode, simplifies the data handling systems at the tracking stations, thereby minimizing the operation and maintenance activities at those locations. As a result, the trend toward the direct transfer of data from the spacecraft to the control center via high data rate communications links is expected to continue.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $3.1 million in the FY 1979 funding level resulted from two factors: (1) the delay in the Shuttle orbital flight test schedule which, in turn, allowed for a delay in ordering up the wideband communications circuits required for Shuttle support and (2) lower than originally estimated prices for some overseas wideband circuits.

NASA TRACKING, DATA ACQUISITION, AND COMMUNICATIONS NETWORK



BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements for communications operations will provide for the circuits and services required to operate and maintain the NASCOM. International communications satellites will permit the extension of additional digital wideband services to all overseas tracking stations. These services will provide for the near real time transfer of data for all on-going flight programs.

The major reason for the increased requirements in FY 1980 is due to the support requirements for the Shuttle flights. This project requires a full year of wideband communications circuits throughout virtually the entire network of stations. Wideband service will also be initiated near the start of the fiscal year to support the Tracking and Data Relay Satellite System (TDRSS) facility testing phase.

The operation of the switching centers and technical control facilities is a continuing function assuring high reliability and efficiency in the use of the various types of communications services available to NASCOM from the common carriers. Funds are included in the FY 1980 request to cover the cost escalation associated with the operation and maintenance of these facilities.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of	Dollars)	
Data Processing Operations........................	28,931	31,700	33,000	34,400

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form for the day-to-day spacecraft operations and for analyzing the experiment data acquired by the spacecraft. This data processing function is performed for a wide variety of programs, which range from the small Explorer satellites to large and complex Solar/Astronomical Observatories and the Landsat Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to compute spacecraft positions. These functions are essential for the real time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft; (b) consolidate information from each experiment;

(c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data are the primary product of the spacecraft missions, and it is through reductions and analyses of these data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive premission orbit studies, including spacecraft position and attitude predictions. Studies are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft.

Two facilities, the Image Data Processing Facility and the Telemetry On-Line Processing System (TELOPS) have been established at Goddard Space Flight Center to process different types of data.

The Image Data Processing Facility, initially established for the support of the first Earth Resources Technology Satellite (LANDSAT-1) to handle imagery data, now supports the second and third LANDSAT spacecraft. Beginning in the second quarter of FY 1979 these spacecraft are supported with a new all-digital system using computer compatible tapes to reduce the time required to provide data to users. The operational requirement for this facility is expected to continue through the next several years for support of the currently operational and/or approved programs including Nimbus 7, Synchronous Meteorological Satellites, Heat Capacity Mapping Mission, and the upcoming Solar Maximum Mission.

The telemetry processing facility which has handled the conventional, nonimagery data, was reconfigured in FY 1978 when the Telemetry On-Line Processing System (TELOPS) was phased in. This reconfiguration resulted in a change from a tape-oriented system to an automated on-line electronic mass storage system. TELOPS receives satellite data in digital form from the tracking stations via NASCOM communication lines and is able to store up to six months of telemetry data on-line, thus eliminating most of the tape and tape handling operations within the old processing facility.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $1.3 million in the FY 1979 funding level resulted from extension of support for the GEOS-3 mission, greater than expected costs associated with bringing TELOPS into full operation and a delay in the operational date for the all-digital system in the Image Processing Facility.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget requirements include funds to operate the Image Processing Facility and the Telemetry On-Line Processing System to process data from currently orbiting satellites, as well as data from the satellites scheduled to be launched during the period. The scientific requirements for the acquisition and processing of data from the older satellites are under continuing review, and support for older missions is terminated or curtailed as mission objectives are achieved or when the experiment data is no longer useful or cost effective to acquire and process.

Software procurement activities have been initiated for support of upcoming space science and applications spacecraft such as the Space Telescope and Dynamic Explorers, as well as Spacelab. The activities cover spacecraft orbit and attitude control and related data processing requirements which require additional funding for FY 1980. Software effort is also required to develop the necessary programs to accommodate the TDRSS/free flyer mode of operation.

As in other areas of operations, escalation is a significant factor contributing to the increased funding level requested for FY 1980 over FY 1979.

BASIS OF FUND REQUIREMENTS:

SYSTEMS IMPLEMENTATION

The objectives of the NASA tracking and data systems implementation program are to maintain the existing ground support capability at a high level of proficiency and reliability in order to meet the aggregate support needs of the many and varied space missions, and to provide augmentation to this capability, as necessary, to meet the special requirements of individual flight projects. These ground support systems consist of the tracking and communications networks, control centers, data processing facilities and aeronautics and sounding rocket instrumentation.

The system implementation program encompasses the engineering, design and procurement of the necessary equipment, subsystems, and systems in response to the requirements of the various flight missions and other research projects. It also includes related documentation and basic software, the provisioning of large module spares, and the acceptance testing, integration and checkout of equipment.

The majority of the FY 1980 funding requested is needed to maintain the required level of operational proficiency and reliability of network systems through the replacement of obsolete and worn-out equipment. Modification and augmentation of existing systems are also necessary to maintain compatibility with changes in associated onboard spacecraft communications systems and to improve the utilization and efficiency of network systems. In addition, FY 1980 funds are also required to continue the implementation of new capabilities for upcoming approved missions, including the International Solar Polar Mission, Galileo, Space Telescope, Shuttle, and Spacelab programs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network.................	18,632	13,000	13,000	17,000
Deep space network..................................	11,640	14,800	12,500	15,100
Aeronautics and sounding rocket support...............	3,095	3,500	3,500	3,700
Communications......................................	3,433	5,100	5,100	3,700
Data processing.....................................	3,600	4,900	6,400	6,900
Total..	40,400	41,300	40,500	46,400

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Spaceflight Tracking and Data Network Systems Implementation.....................................	18,632	13,000	13,000	17,000

OBJECTIVES AND STATUS:

The Spaceflight Tracking and Data Network Systems Implementation program encompasses the procurement and implementation of systems and services necessary to sustain an effective capability for reliable support of ongoing scientific and applications satellite missions, to assure network capabilities for efficient tracking, command, and data acquisition support for all NASA manned and unmanned earth orbital missions, and to meet new support requirements for spacecraft to be launched in the near future. Implementation of these capabilities is vital to the success of NASA's spaceflight missions.

Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, and command. Among these are the International Sun Earth Explorers (ISEE 1, 2, and 3), the High Energy Astronomy Observatories (HEAO 1 and 2), LANDSATS 2 and 3, Nimbus 6 and 7, and the Laser Geodynamic Satellite (Lageos). Network and control center systems are in the final stages of implementation for upcoming new missions such as the Space Shuttle Orbital Flight Tests, Stratospheric Aerosols and Gas Experiment, Solar Maximum Mission, and the Magnetic Field Satellite (Magsat). Plans and procurements are also underway to meet support requirements for future missions such as the Space Shuttle operational flights, Spacelab, LANDSAT-D, and the Space Telescope.

BASIS OF FY 1980 ESTIMATE:

Equipment modifications are required in the network and control centers in FY 1980 to maintain the required level of proficiency for support of a diverse and demanding workload and to assure the reliability of the network systems. Accordingly, funds are required for replacement of worn-out systems with more reliable units, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

The operational flights of the Space Transportation System (STS) will employ the Tracking and Data Relay Satellite System (TDRSS) for orbital tracking and command and for data, television, and voice communications. A comprehensive capability for prelaunch testing and launch support of Shuttle and for compatibility testing of Shuttle and STS payloads with TDRSS is being installed at the Merritt Island, Florida, network station. Funds are requested in FY 1980 to complete the Merritt Island station TDRSS compatibility test capability and to complete the STS and STS payload telemetry and command monitoring systems at the TDRSS ground station at White Sands, New Mexico. Funds are also included for the continued implementation of mobile compatibility test vans to be used for prelaunch free flyer spacecraft/TDRSS compatibility testing.

In addition, funds are requested to procure a transponder test set to maintain and calibrate the TDRSS bilateration tracking systems funded in FY 1978 and FY 1979. The bilateration tracking system is required to obtain precise position information on the TDRSS. Precise position of the TDRSS spacecraft is necessary in order to calculate precise orbits of the spacecraft being tracked by TDRSS. Data from the bilateration tracking systems will be processed by the Goddard Space Flight Center employing existing orbit computation capabilities to obtain precision orbits for TDRSS supported spacecraft in the same manner as orbits are presently calculated using data obtained by the network ground stations.

In FY 1980, activities will continue to design and implement a new control center for the Space Telescope. This work will be conducted in concert with the development of the Science Institute (funding by Office of Space Science) to minimize the design cost for both hardware and software systems as well as to facilitate testing and other operations.

Tape recorders for LANDSAT-3 support will also be procured in FY 1980. These recorders will be located at several foreign locations as a backup recording capability to insure a continued flow of LANDSAT-3 data in the event of failure of the LANDSAT-3 onboard tape recorders.

To meet the mission control workload in the 1980's, a new approach to control center design has been initiated in FY 1979. This approach involves techniques for rapid configuration of control center equipment to meet the requirements of a particular mission. The overall objective of the new design is to permit the sharing of resources to improve equipment utilization and to decrease the number of software and operations personnel. In Fiscal Year 1980, the necessary complement of computers will be purchased and the integration of a "cluster" of control centers undertaken.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Deep Space Network Systems Implementation.............	11,640	14,800	12,500	15,100

OBJECTIVES AND STATUS:

The Deep Space Network is responsible for recovering science data from and providing the capability for remote operation of planetary and interplanetary spacecraft. The systems and facilities required to accomplish this are highly specialized and include Deep Space stations with their large aperature antennas (up to 64-meter diameter), ultrasensitive receivers, and high power transmitters. Advanced data handling systems are also required both at the stations and in the network control center.

The Deep Space Network Systems Implementation program provides for procurement of the systems and related services to be used in this network to assure that its capabilities keep pace with ongoing and upcoming approved planetary mission support requirements. It also provides for the replacement of obsolete equipment in order to improve the performance, reliability, and maintainability of the network. The equipment and techniques funded under this program are a major contributor to: improvements in spacecraft navigation accuracy; the successful conduct of increasingly complex experiments; and the ability to receive increasing amounts of scientific information from planetary spacecraft at ever increasing distances from Earth. The need for dedicated network support during many time-critical mission events combined with the increasing communication distances and the demand for greater ground navigation precision, requires a continuing effort to extend network capabilities, performance, and reliability.

During FY 1980 the network will be nearing completion of the provisioning of 3 of its 26-meter antennas with an X-band capability and making final preparations for the Voyager Saturn encounters which occur in FY 1981.

At the same time increased effort will be expended towards preparing the network for the complex and difficult tasks of supporting the launch, Mars encounter, and cruise phase of the Galileo mission, and the dual spacecraft NASA-European Space Agency International Solar Polar Mission.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $2.3 million from the FY 1979 budget estimate resulted from the Congressional appropriations action which deleted funding for the search for extraterrestrial intelligence (SETI) research and imposed a general reduction which necessitated an additional delay in the replacement of obsolete computer equipment at the DSN stations.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding will provide for completion of a portion of the navigation improvements required for Voyager Saturn encounter support are being deferred from FY 1979. FY 1979 funds originally planned for this purpose are being used for network modifications necessitated by an anomaly in one of the Voyager spacecraft's receiving systems. Additional funding for Voyager support has also become necessary due to an adjustment in the Saturn encounter trajectory changing coverage requirements so that microwave equipment previously planned for implementation at only the 64-meter station in Spain will also be necessary at the 64-meter station in Australia.

As part of a phased program initiated in 1976, one subnet of 26-meter antenna facilities is being augmented with an X-band reception capability, which includes an expansion of the antenna aperature to 34 meters. FY 1980 funds will complete these modifications, thus providing a 34-meter antenna with X-band reception capability at the three major DSN locations to provide relief for the extremely overloaded 64-meter facilities. These antennas with their expanded telecommunications capability are initially required for support of the post-Jupiter cruise phase of the Voyager mission and will also be used in combination with the 64-meter antennas to significantly increase the amount of scientific data which can be returned from the Voyager Saturn encounters. They will also provide a vital telecommunications capability for the International Solar Polar Mission and the cruise phases of the Galileo mission.

The development of Very Long Baseline Interferometry (VLBI) tracking techniques and the increased need for planetary missions to obtain high accuracy ground navigation places a significant support workload on the 64-meter stations which are the only facilities presently equipped for this task. Commencing in 1982, the network will be required to support the Galileo flyby of Mars enroute to Jupiter and the Voyager cruise phase to Uranus, both of which will use VLBI for navigation. The critical Mars flyby in particular, will require support by the 64-meter antenna facilities, leaving little if any support time for Voyager. Therefore, FY 1980 funds will be used to initiate the necessary modifications at the 34-meter antenna facilities so that this support workload can be shared with the 64-meter antenna facilities.

The replacement of obsolete data handling computers which was delayed from the FY 1979 budget will be initiated in FY 1980. The computers presently in the network were originally installed in 1964 and new replacement components are no longer available. FY 1980 funds are also required to maintain the high level of reliability required to support critical one-time mission events. This can only be accomplished through a continuing program of spares provisioning, maintenance support and minor equipment modifications to improve reliability, upgrade equipment performance and to provide for the interfacing of existing equipment with the new systems being added in the network.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and Sounding Rocket Support Systems Implementation..............................	3,095	3,500	*3,500*	3,700

OBJECTIVES AND STATUS:

The aeronautics, balloon, and sounding rocket programs are supported at the Wallops Flight Center in Virginia, and the Dryden Flight Research Center in California.

The aeronautics program support at Wallops consists of model and/or instrumentation drop tests utilizing helicopter or fixed-wing aircraft, aircraft noise abatement projects, slow speed landing techniques for jet aircraft, antiskid tests on grooved runways, vertical/short takeoff and landing (V/STOL), terminal area research, microwave landing system development tests, collision avoidance programs and remote (airborne) sensing developments in support of the earth resources programs.

The sounding rocket programs supported at Wallops cover all the atmospheric and space disciplines in which research is undertaken, utilizing a family of launch vehicles varying in size and power from the small meteorological rockets to the 72-foot Scout with orbital capability. Approximately 300 sounding rockets are launched annually from Wallops Island and remote sites around the world, carrying experiments in the field of Aeronomy, Energetic Particles, Ionospheric Physics, Meteorology, and Solar Physics. Of particular interest is the current effort to measure the effect of aerosols on the protective layer of ozone in the upper atmosphere which filters out harmful solar radiation and the measurement of other compounds such as nitric oxide as part of the environmental observations program.

To provide instrumentation support to these programs, fixed and mobile ground support equipments are provided by Wallops. To maintain these equipments, spare and replacement parts are required, as well as some non-recoverable flight hardware such as on-board antennas and transponders. To meet specific test requirements, modifications and augmentations of selected telemetry, communications, tracking, command, and data handling systems are required. In addition, the mobile equipment must be periodically refurbished and modified to meet remote site requirements such as the ongoing meteorological program in cooperation with several nations, including Argentina, Brazil, and Spain.

The aeronautical research and technology programs supported by the Dryden Flight Research Center (DFRC) consist of high altitude and terminal area tests involving high performance aircraft such as the F-111, F-15, F-104, F-8, Remote Piloted Vehicles including HiMAT, and various other aircraft and helicopters. Dryden Flight Research Center was responsible for the Approach and Landing Tests for the Shuttle Orbiter in 1977 and will support the Orbital Flight Tests beginning in 1979. The ground support equipment is located on the Aerodynamics Test Range, which consists of stations at the Dryden Flight Research Center and Ely, Nevada. Operational responsibility for the Ely, Nevada station will be transferred to the Air Force in early 1979. High precision radar, telemetry data handling, and associated timing, communications, and command systems are maintained and modified to meet the changing requirements of the approved flight projects.

BASIS OF FY 1980 ESTIMATE:

The FT 1980 funding requirements will provide the sustaining equipment and modifications to support the sounding rocket and aeronautics program described above.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Communications Systems Implementation................	3,433	5,100	5,100	3,700

OBJECTIVES AND STATUS:

The objective of the Communications System Implementation program is to provide the necessary capability in NASA's global communications network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and *to* keep NASCOM at a high level of reliability for the transmission of data.

NASCOM interconnects the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget request provides for network equipment to increase the performance in handling data, continuing with the automatic switching capability for TDRS data and the data recall system for error control on overseas high data rate lines.

Also included in the FY 1980 budget request are funds for a continuing effort to improve the data transmission and performance monitoring capabilities of the NASCOM as the use of digital techniques expand to handle the higher data rates of the flight projects. The use of the digital mode requires specialized and automated equipment to transmit the data over the leased communications circuits at the rates utilized by NASA.

With the use of digital techniques, it becomes increasingly cost effective to use wideband circuits in NASCOM to "bent pipe" data from the stations to the control centers. Wideband terminal and interface equipment will continue to be procured in FY 1980 as the common carriers make available a greater variety of wideband communications services at an economical price.

To maintain system reliability, a continuing program to procure replacement parts, spares, test and monitoring equipment is necessary. Funds for this purpose are included in the FY 1980 request.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Data Processing Systems Implementation.................	3,600	4,900	6,400	6,900

OBJECTIVES AND STATUS:

The Data Processing Systems Implementation program provides for the procurement of equipment and related services to sustain the large computer complexes at the Goddard Space Flight Center (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements these computer complexes, utilizing sophisticated software programs, determine spacecraft attitude and orbit, generate commands to the spacecraft and provide the status of onboard subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters.

Several significant activities in this program are underway at GSFC. The Telemetry On-Line Processing System (TELOPS) became operational during 1978 and is now successfully supporting a number of spacecraft, including the recently launched HEAO-2. The Image Processing Facility has been augmented at GSFC and has begun to produce output products for LANDSAT, Heat Capacity Mapping Mission, and Nimbus-7. Procurement of a computer system will be initiated during FY 1979 to replace the aging system that provides a metric tracking data base for orbit computation. Modifications will also be started so that TELOPS can handle the data formats for the early Spacelab missions.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $1.5 million in the FY 1979 funding level resulted from the requirement to implement an interim Spacelab data processing capability for the early Spacelab missions.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget request will provide initial funding for partial replacement of the existing computer complex at the Goddard Space Flight Center which provides real time support to the many NASA spacecraft. Included in the support are such critical activities as real time attitude and orbit determination, memory management for onboard computers, and flight maneuver control. By FY 1980, this computer complex will be approximately 15 years old. Not only are the hardware and software maintenance becoming more difficult and expensive, but the growing unreliability creates an increasing risk to reliable spacecraft operation. Further, their system architecture requires greater software expenditures to adapt to new missions. Funds are also requested to complete certain system procurements, including the interim Spacelab data processing facility and the Flight Maneuver Operations Control (FMOC) backup system.

Under the sustaining program, there is a continuing requirement to procure and maintain adequate supplies of spare parts, replace failure prone and high maintenance electronic modules, provide test equipment and undertake minor modifications and hardware fabrication associated with new equipment installation and equipment reconfiguration.

BASIS OF FUND REQUIREMENTS:

ADVANCED SYSTEMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Systems	9,316	9,900	9,900	10,600

OBJECTIVES AND STATUS:

Under the Advanced Systems program studies and developments are conducted (1) to obtain new and improved capabilities to meet the needs of upcoming missions and programs, and (2) to investigate advanced techniques and to identify the required technology for support of upcoming missions, and (3) perform ground systems studies to determine, for example, the lowest life-cycle costs for support of future space missions.

BASIS OF FY 1980 ESTIMATE:

One of the more specific objectives of the Advanced Systems program which characterize the efforts planned for FY 1980 is to improve the ground-based navigation accuracy of the Deep Space Network (DSN). Prior advanced systems efforts have resulted in studies and experiments which now make it possible to have an increased navigation accuracy in support of planetary missions. Current accuracy of the DSN for tracking and guidance of planetary missions is approximately 100 Km out to the distance of Mars. Ground-based navigation for future planetary spacecraft requires tracking to about 5 to 10 Km accuracy at Mars distance and 100 Km at the outer planets. Missions of the future that require navigation accuracy improvement include outer planet gravity-assist swingbys and orbiters, outer planet satellite flybys and probes, and non-ballistic, low thrust missions.

Investigations involving the use of Very Long Baseline Interferometry (VLBI) now promise further improvements in ground-based navigation accuracy by a factor of 100 under some conditions. Several new navigation techniques based on VLBI have been or are under development. One, for example, will be demonstrated in 1979 during the Voyager encounter at Jupiter. In this demonstration navigation accuracy will be provided through measurement of angular position difference between spacecraft and a succession of well established quasar star positions. This system will be used later in the Voyager encounter with Saturn and the critical Galileo Mars flyby.

Also under development for experimental use during the Galileo Mars flyby is a further refinement in VLBI techniques which will allow a factor of 10 improvement in ground-based navigation accuracy over the sytem previously described for Voyager. Success with this experiment will enable the network to pinpoint the location of Galileo to about 10 Km (6.2 miles) as it flies by Mars. Such precision will reduce the number of mid-course corrections, with resultant savings in spacecraft fuel. This fuel conservation will permit the flight project to maximize the number of Galileo encounters with the satellites of Jupiter in the later phases of the mission. Under the Advanced Systems program, this technique will continue to be evaluated for future applications particularly with respect to ultra-precise orbiter mission requirements.

Laser ranging technology used in the tracking of satellites such as LAGEOS is also being developed for space applications particularly the Earth crustal dynamics program. Best accuracy now obtained is 10-50 centimeters, but 2-5 centimeter accuracy is needed for our mobileranging stations in order that geologists can better study the Earth's crust and its relationship to earthquakes.

Ground-based technology for radio telecommunications will also be developed in order to support future spacecraft command and data acquisition requirements. Future planetary missions require rates in excess of 60 kilobits (more than twice current capability) from Saturn, a distance of approximately 1.5 billion kilometers from Earth. Future earth orbital missions with new high resolution sensors for monitoring the Earth's surface and its environment require telemetry rates approximately 10 times current network support capabilities. To meet these needs advanced systems work will be conducted on more efficient antenna feeds and configurations, high sensitivity receiving systems, improved microwave component technology, and methods to monitor and avoid increasing radio frequency interference being experienced from sources outside the area of our stations.

Methods of providing tracking and data acquisition support which are more cost-effective than those currently used will also be investigated. These include very small antennas for broad beam surveillance of spacecraft to release large facilities from routine acquisition of housekeeping telemetry; techniques for automation of station and control center functions; the desirability and feasibility of using an Earth orbiting satellite to relay data from deep space missions and localized use of fiber optics for wideband data switching and transmission.

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